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ABSTRACT

This study examined two major areas: (1) evaluation of the characteristics, interactions, problem-solving strategies and achievement of seventh- and eighth-grade junior high school students (N=66) as they interacted with a microcomputer in three problem-solving sessions, and (2) determination of the effectiveness of three original microcomputer programs using topics from life science, social studies and environmental science in problem-solving, and a fourth program in specific skill training in organizing data using a matrix. Selected conclusions indicated that: (1) students can improve in problem-solving skills in a short time on a microcomputer; (2) the training session in organizing data into a matrix was successful in introducing a usable new strategy; (3) individuals worked better in teams than alone; (4) subjects were just as motivated when sessions were more infrequent; (5) influence of group interaction enabled subjects of all abilities to successfully participate in and solve problems; (6) all subjects adapted easily and quickly to the use of a microcomputer; (7) subject interest remained high regardless of achievement or variances of individual characteristics; and (8) microcomputers can be considered a viable, motivating aid for the development of some problem-solving skills of early adolescents. (Author/JN)

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# EARLY ADOLESCENT USE OF SELECTED PROBLEM-SOLVING SKILLS USING MICROCOMPUTERS

by

Dorothy Anna Howard Cox

A dissertation submitted in partial fulfillment
of the requirements for the degree of
Doctor of Philosophy
(Education)
in The University of Michigan
1980

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Professor Carl F. Berger, Co-Chairperson
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Professor Burton E. Voss
Lecturer Karl L. Zinn

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# ABSTRACT

## EARLY ADOLESCENT USE OF SELECTED PROBLEM-SOLVING SKILLS USING MICROCOMPUTERS

by
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Co-Chairpersons: Carl F. Berger and William B. Stapp

This study examined two major areas: (1) evaluation of the characteristics, interactions, problem-solving strategies and achievement of junior high school students as they interacted with a microcomputer in three problem-solving sessions, and (2) determination of the effectiveness of three original microcomputer programs in problem-solving, and a fourth program in specific skill training in organizing data.

Subjects included sixty-six seventh and eighth grade students enrolled in four junior high schools in middle class communities in suburban metropolitan Detroit, Michigan. Forty-eight males and eighteen females volunteered from various classes. Research methods based on a quasi correlational design utilized multiple regression analysis to test the major hypotheses of the study. The study focused on five problem-solving skills selected from the ten-step sequential Stapp and Cox problem-solving model: collecting, organizing, and analyzing information, developing alternatives, then developing a plan of action.

Three interactive problem-solving microcomputer programs using topics from life science, social studies, and environmental education were constructed by the researcher. In addition, a training program to organize data using a matrix was developed to determine the effect

of controlled interactive training on the solution of the given problems. A cognitive inventory analyzed the students' background knowledge.

Subjects were randomly assigned to either work alone or in groups of two, three, or five for three sessions, each lasting fifty minutes. Half the subjects met on three consecutive days, the other half met once a week. Half of each of the above groups received special training on organizing data at the beginning of the second session, the other half received no special training.

Data for subject identification, time and clues needed for solution, and order of clues were saved within the memory of the microcomputer for later retrieval. Anecdotal observations of subjects with other subjects, and with microcomputers were recorded. Program difficulty, interactions, problem-solving strategies and achievement over the three program sessions were analyzed.

Selected statistically significant findings of the study were: (1) subjects improved their problem-solving by decreasing the time required for solution in successive programs; (2) subjects who participated in a training session to organize data were likely to use the matrix strategy to solve similar problems; (3) matrix training was more useful for subjects who worked once a week than for those who worked daily; (4) use of the matrix strategy did not improve time needed to solve problems; (5) group size was related to the time required to reach a solution and the achievement of a correct solution (teams of five took the least time, but teams of two and three solved more problems with greater consistency); (6) there were no differences in number of problems solved between daily sessions and once-a-week sessions; (7) the size of the group had the most influence in overall problem-solving achievement; (8) frequency of session and grade average were significant predictors of the number of problems solved; and, (9) matrix training and grade average were significant predictors of the use of the matrix.

Selected conclusions indicated that: (1) students can improve in problem-solving skills in a short time on a microcomputer; (2) the training session in organizing data into a matrix was successful in introducing a useable new stragegy; (3) individuals worked better in teams than alone (the optimal size working group was more than one and less than five); (4) the subjects were just as motivated when sessions were more infrequent; (5) influence of group interaction enabled subjects of all abilities to successfully participate in and solve problems; (6) all subjects adapted easily and quickly to the use of a microcomputer; (7) subject interest remained high regardless of achievement or variances of individual characteristics; and, (8) microcomputers can be considered a viable, motivating aid for the development of some problem-solving skills of early adolescents.

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No words can adequately convey my appreciation for the many contributions of my husband, James Cox. Without his skillful, creative programming of my word ideas for the microcomputer, this research would not have been possible. The untold hours of programming, reprogramming, practical suggestions, and cheerful editing have made this truly our dissertation.

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# CHAPTER I

# THE INTRODUCTION

For the past two decades, science educators have expressed a need for a major focus on the development of scientific literacy in science education. The National Science Teachers Association Position Statement on School Science Education for the 70s defined a scientifically literate citizen as one who is a personally concerned individual with a high competence for rational thought and action. They described this choice of goals as based on the belief that achieving scientific literacy involves the development of attitudes, process skills, and concepts necessary to meet the more general goals of all education. Renner, Stafford and Ragan (1973) believed that in our complex world, in order to make intelligent judgements, a citizen must not only possess information but know how to interpret it.

In a wider scope, the interdisciplinary area of environmental education focuses on the development of a literate world population which is not only aware of and concerned about the total environment and its associated problems, but has the knowledge, attitudes, motivations, commitments and skills to work individually and collectively toward solutions of current problems and the prevention of new ones (Stapp and Cox, 1979). Such a relevant, active problem-solving process has been found to be valuable in community environmental problem-solving throughout the United States and in many countries throughout the world.

In recognition of the importance of this concept, the Declaration of the Tbilisi Intergovernmental Conference on Environmental Education in 1977 declared, "Environmental education must look outward to the community. It should involve the individual in an active problem-solving process within the context of specific realities ...." ("Toward An Action....," 1977).

In order to become involved in community problems and their solutions, it is necessary to learn the skills needed to follow a problem-solving process through from problem recognition and definition to an action plan and execution. One way to develop this kind of literate, competent, concerned citizenry is for schools to provide children with a diversity of experiences which will help to develop these necessary problem-solving skills. In the developed world nations, particularly Japan, West Germany, the United Kingdom and the United States, electronic technological advances have provided new and unique aids which may prove to be a valuable addition to the diverse strategies already available to develop and improve desired problem-solving skills.

In 1975 a technological breakthrough introduced the microcomputer to the general public. Although slow to utilize this electronic micro-processor, educators are now beginning to realize that this compact, relatively inexpensive microcomputer may provide a way to motivate students to develop a high level of competence in rational, logical thinking. With the aid of a computer, an individual can input information and perform very complex analyses and interpretations. When the student programs the computer to analyze his data, it is possible to reach an even higher level of rational thought (Doerr, 1979). Although there is considerable research concerning large computer systems (See Chapter II) as they relate to education (generally higher education), there is no known published research at this time on the use of microcomputers relating to student learning and problem-solving in education.

## The Statement of the Problem

Science and environmental educators should seek ways of developing relevant problem-solving skills utilizing not only established effective educational methods, but also exploring the utilization of new technological tools. An important first step in tapping one of the newest in available technology is the establishment of baseline data regarding the use of the microcomputer as an unique, but untried, aid in the training and successful development of problem-solving skills.

The purpose of this thesis was to study early adolescent use of selected problem-solving skills using microcomputers. The methods and procedures included the development of a series of three complex problem-solving situations unfamiliar in strategy of solution to the average junior high school student in the study, the development of an interactive microcomputer training session in the skill of organizing data, the provision of opportunities for students to interact with these problems in planned sequences on a microcomputer, and the evaluation, statistically and anecdotally, of the characteristics and relationships of these interactions. The ultimate goal was the development of a scientifically, technologically and environmentally literate citizen.

## Background and Need for the Study

The problem statement and purpose identified two general areas for which the development of background information would better introduce the reader to the importance and need for this study. These two areas are the complex definitions and descriptions of "problem-solving" and the explosive growth of the microcomputer industry and its educational adaptations and implications.

### Problem-Solving

Problem-solving is a complex process that is recognized by many educators as a vital, necessary part of not only mathematics, science and social studies education but each individual's daily life (Doerr, 1979; McGuire, 1973; Yinger and Eckland, 1975). Gagne (1963) regarded problem-solving as the highest in his hierarchy of human capabilities. Taba (1962) discussed problem-solving as an intellectual skill identified with thinking and emphasized the importance of intelligent and independent thought in everyday life. Stapp and Cox (1979) regarded problem-solving as an integral part of the development of an environmentally literate citizen.

Few authors agree on the specific characteristics or steps of a problem-solving process. Bruner (1961) defined "inquiry" as being composed of "problem-solving" activities which include trying out an idea, forming an early hunch, and posing good testable hunches.

Taba (1962) discussed problem-solving steps of problem identification and analysis, formulating hypotheses and gathering data, and experimenting with action. John Dewey (1910) described problem-solving as having six steps:

1. Motivation to resolve problems,
2. Analysis and diagnosis,
3. Search for alternative solutions,
4. Evaluation of alternatives for their consequences,
5. Experimental trying out of one alternative, and
6. Acceptance or rejection of that alternative.

Wallas (1926) listed four general phases: preparation, incubation, illumination, and verification. Polya (1968) lists four different steps: understanding the problem, devising a plan, carrying out the plan, and looking back. Simon and Newall (1971) do not list steps but describe problem-solving as a "sequential search which adds small successive accretions to the store of information about the problem and its solution."

Some definitions and descriptions describe problem-solving only as a thinking process, many involve a sequence that begins with recognition and evolves through a thinking process to a solution, and some include an action phase and evaluation. Others, such as AAAS, focused more on separate component processes and much less on a sequence of skills leading to a solution and action.

In the past decade, science educators have identified specific components of problem-solving and centered their hands-on, inquiry curriculum on developing the ability of students to use these components. A well defined list of these individual component processes has been identified by the American Association for the Advancement of Science (AAAS) which placed a strong emphasis on developing the ability of students to employ these processes of science to learn about phenomena of the natural world, pursue scientific investigations, and use in everyday life. In the "Science ... A Process Approach" program (SAPA), AAAS identified the following eight basic processes and five integrated processes:

Basic Processes

1. Observing,
2. Inferring,
3. Using time and space relationships,
4. Using numbers,
5. Measuring,
6. Communicating,
7. Classifying, and
8. Predicting.

Integrated Processes

1. Formulating hypotheses,
2. Controlling variables,
3. Defining operationally,
4. Interpreting data, and
5. Experimenting (a cumulative process).

These processes have not been necessarily developed or practiced sequentially. The integration of these individual components has been expected to occur in secondary school laboratory experiments and investigations.

These individual processes were considered so basic that application to daily living was expected to occur naturally outside the discipline of science. It has been the author's experience as a classroom teacher of many years, that such relevant applications have not naturally occurred. Such intuitive leaps need direction and practice. According to the Progressive Education Association's Eight Year Study in the 1930s, problem-solving should be a total process beginning with the problem and ending with action (Tanner and Tanner, 1975).

Bridging the gap from fragmenting and integrating to a sequential step-by-step total process, has been the environmental education problem-solving process described by Stapp and Cox (1979). Problem-solving skill development was described as an essential ingredient in an instructional model in which the emphasis was placed on relevancy, motivation and commitment to work toward a quality environment and life style. Cognitive or technical knowledge alone may not increase concern. In a study by Swan (1969) it was concluded that the most informed city youth at Mackenzie High School in inner-city Detroit had the least concern about the air pollution problems afflicting their area. Active participation in the problem-solving process has been found to be necessary for the concern, commitment and achievement of instructional goals. The problem-solving steps that have been effective in this process, as described by Stapp and Cox, are to:

1. Recognize the problem,
2. Define the problem,
3. Listen with comprehension,
4. Collect information,
5. Organize information,
6. Analyze information,
7. Generate alternative solutions,
8. Develop a plan of action,
9. Implement a plan of action, and
10. Evaluate the plan of action.

In the past decade of use of this total strategy in community problem-solving activities, there has been felt a continuing need to improve process skills to make the overall strategy more effective.

Highly developed process skills cannot be assumed to be available to facilitate a total process any more than application can be assumed when individual process skills are developed and practiced. It is desirable and necessary to keep the total sequential strategy in mind as the ultimate purpose or goal and apply those learned skills.

In Figure 1 the relationship, or interface, between the various "steps," "phases," "sequences," and component "processes" are shown. It becomes apparent that most of the differences in these theories and descriptions lie in the semantics, complexity, and whether an action phase was included or not. The Stapp and Cox model is closely aligned to Dewey's six steps, includes all the AAAS processes, and includes the general outlines of steps delineated by the other educators. For these reasons the Stapp and Cox, personally-oriented, sequential problem-solving model has been selected as the theory base for this study.

In working with this ten-step problem-solving strategy with adolescents, it has become apparent to the author that a key determiner of success was knowing what to do with the information supplied (see Pilot Study 1 in Appendix H). This conclusion was supported by Greeno (1978) in a discussion of problem-solving in geometry. He suggested that while students can almost always follow the inferential steps of a problem solution, they have great difficulty anticipating or organizing those steps. "Strategic knowledge is required ... and may be the most crucial ... in determining successful problem-solving."

Five steps of the Stapp and Cox (1979) sequential

| DEWEY (1910) | WALLAS (1926) | POLYA (1968) | SIMON & NEWALL (1971) | AAAS (SAPA) (60s & 70s) | STAPP & COX (1979) |
|---|---|---|---|---|---|
| 1. Motivation | 1. Preparation | 1. Understanding the problem | | 1. Defining operationally | 1. Recognize the problem |
| | 2. Incubation | | | | 2. Define the problem |
| 2. Analysis & Diagnosis | | | | 2. Communicating | 3. Listen with comprehension |
| | | | A sequential search which adds small successive accretions to the store of information about the problem and its solution | 3. Controlling variables | 4. Collect information |
| | | | | 4. Observing | |
| | | | | 5. Using numbers | 5. Organize information |
| | | | | 6. Measuring | |
| | | | | 7. Classifying | |
| | | | | 8. Using space/time relationships | |
| | 3. Illumination | | | 9. Interpreting data | 6. Analyze information |
| | | | | 10. Inferring | |
| 3. Alternative Solutions | | | | 11. Predicting | 7. Generate alternative solutions |
| 4. Evaluate alternatives for consequences | | | | 12. Formulating hypotheses | |
| 5. Trying out one alternative | | 2. Devising a plan | | 13. Experimenting | 8. Devise a plan of action |
| | | 3. Carrying out the plan | | | 9. Implement plan of action |
| 6. Acceptance or rejection of that alternative | | 4. Looking back | | | 10. Evaluate the plan |

Figure 1. An Interface of Problem-Solving Characteristics

problem-solving model require skills of "strategic knowledge": collecting, organizing, and analyzing data to reach a workable solution. These five skills include steps four through eight of the problem-solving model:

1. Recognize the problem,
2. Define the problem,
3. Listen with comprehension,
4. Collect information,
5. Organize information,
6. Analyze information,
7. Generate alternative solutions,
8. Develop a plan of action,

Focus for Study

9. Implement a plan of action, and
10. Evaluate the plan of action.

By eliminating the first three and last two steps, the study could be focused on the way data was collected, organized, and analyzed. The problem was easily displayed on the microcomputer screen (steps one and two). Listening did not apply to this visual presentation of problem components (step three) and the study was not intended to extend to an action phase of community problem-solving (steps nine and ten).

Wollman (1978) declared that strategic knowledge or heuristics can be learned and that "if they can be learned there must be a way to enhance that learning." It was the purpose of this study to explore the use of these five specific skills by early adolescents. Enhancement of such learning may be provided by the development and use of creative programming on a new technological tool, a microcomputer.

## Microcomputers

> I believe the future computerized society so frequently talked about is here now. It's no longer somewhere in the future. Today's use or misuse of the computer will affect the future. ... Teachers, children and parents must be shown that these electronic machines are tools invented by people to aid learning and creation.
> (Stavrides, 1978)

A research project, sponsored by the United States Office of Education in the Department of Health, Education and Welfare, sought to envision the secondary school of 1980-2000 and to develop a working model of 21st century schooling. Among the conclusions of this team of educators, engineers, mathematicians and scientists were that technological advances are expected to have a major impact on society and that education would include greater use of educational technology from visuals to computers (Elliott, 1976).

Businesses have enjoyed the advantages of electronics for years; to improve competition, reduce labor costs, and to organize, direct and speed their business transactions. Telephones, microwave ovens, late model cars and bank deposits are directed and regulated by computers. Computerized systems provide the general public with thermostats that not only control heat but give the time of day and the outside temperature. An electronic "know-it-all" for a car gives instant miles per gallon, time of arrival, and miles to go. It has been estimated that the average American uses at least 15 computers a day. The industrialized world has entered into a technological age where computers are a part of the daily lives of every citizen. Zinn (1979) believed that educators need to realize this pervasiveness of computing in all aspects of life when planning uses in education.

Bell (1979) suggested that "History shows that many technological innovations that could be quite useful in promoting learning in schools do not get much use in schools until after they are common in homes and on the street ...." To support this, Lichtman (1979) found in a survey of educator's attitudes toward computers that, in general, educators seemed less enthusiastic about the computer's role than did the general public. But it is that same general public that has been developing a growing insistance that the schools provide their children with computer literacy (Goldberg, 1980).

Computers in the past were considered to be the tools of mathematicians, scientists and business persons (Inman, 1979) but are now becoming a part of "hundreds, if not thousands of classrooms across the country" (Campbell, 1979). Zinn (1979) described the business of education as information processing; "thus the computer, being a processor of information, is a significant tool for ... education."

Revolutionary changes in electronic processors offer new, economical tools for teaching not envisioned a decade ago (Tinker, 1979). With the technological breakthrough of the miniaturized printed circuits in the early 1970s, general-purpose, tabletop microcomputers became a marketable reality in 1975, now costing little more than much of our ordinary audio-visual equipment. To document the microcomputer's mushrooming popularity, a research team determined that approximately 200,000 microcomputers were sold in

1978 alone (Craig, 1979) and over 250,000 in 1979 (Barrette, 1980). Barrette also described a two-year multimillion dollar study that projects that in 1987 over 400 million intelligent electronic modules will be sold in the United States alone, not to business or industry, but to the consumer market. Doerr (1979) maintained that the advent of the low-cost microcomputer has ushered in a new era for teachers interested in using computers in their classrooms. "At last average teachers with average students have the opportunity to augment their teaching effectiveness with this tool of technology."

Microcomputers have been envisioned as providing many services to education. Doerr (1979) suggested that microcomputers offer the following to education: relevant education, opportunities for great teaching because of the alliance between computer and teachers, increased student motivation, feedback for student and teacher, and individualized instruction. Zinn (1979) described six roles for the microcomputer: a delivery system, an assessment tool, a management aid, a development system, a study aid, and a research tool. Campbell (1979) claimed that the microcomputer's major advantage is to multiply and replicate the work of good teachers.

However, until teachers become proficient in programming or have access to support programming personnel, they are limited to available published educational materials or programs and ideas traded with a fellow microcomputer user. Most commerical materials have usually not been appropriate to accomplish specific educational tasks in an individual classroom. Since microcomputing has been in its infancy with considerable growing pains, much of the available material has been of questionable educational value. The possibilities, however, are only limited by the programmer's creativity. One of the purposes of this study was to determine the usefulness of the computer adaptations of the author's original problem-solving programs in the development of specific problem-solving skills.

More subtle, but very real, benefits provided to education by microcomputers have been an increased student and faculty enthusiasm generated by a feeling of "ownership" (Scherer, 1979), more lively and interesting applications in the classroom (Inman, 1979) and a feeling of personal freedom as students gain real control over what they learn and how they learn it (Bell, 1979).

These kinds of positive attitudes counteract the everpresent problem of how to motivate students. One of the accepted principles of learning was described by Taba (1962): a motivated learner acquires what he learns more rapidly than one who is not motivated. Bruner (1965) maintained that the attitudes of a learner are vital to learning yet his earlier writings took motivation for granted--built into the excitement of "discovery." Several years later, Bruner (1971) recognizing his early omission, stated that motivation cannot be assumed and regarded a major issue in education to be to give back the initiative to the student by devoting considerable time in the curriculum to relevant concerns.

As discussed above, microcomputers may be considered relevant. Larsen (1979) stated that microcomputers are "highly motivating for children whose abilities range from average to very bright." But what about the full range of student ability? Will only the above average student volunteer for microcomputer sessions?

Doerr (1979) reflected from her experiences that "this is one novelty that doesn't appear to wear off." Windbigler (1978) observed that students look forward to the "computer's" evaluation of their work: "I am endlessly amazed at how hard a student will work just to be called a 'fledgling chemist' by a piece of hardware." The motivation has been shown repeatedly to be provided by this technological hardware and the ease of the student in interacting with it.

Microcomputer users in education have just begun to explore the variables of student-computer interaction. Many questions have been raised such as; should this interaction be an individual process? If groups are used, how many should be involved? Larsen (1979) claimed that pairs of children on a microcomputer seem to work best, "for one child alone gets 'stuck' too often, and three or more argue over who will type on the console." To attempt to answer this question, this study utilized individuals, and groups of two, three and five students.

Other questions were raised from non-computer interaction studies. Hare's (1952) basic premise in this study of groups was that size is a significant determining factor in group interaction. Shaw (1932) observed that groups have a greater proportion of correct solutions because in a group incorrect solutions will be rejected and errors can be checked, while an individual person may not carry out these aspects. Barnlund (1959) found that "group decisions were clearly superior to individual decisions. In some instances, groups of the least competent subjects were, through discussion, able to surpass the decisions made by the most talented person working alone." There seemed to be a group synergy that keeps a team working on a problem solution long past the point when an individual might give up in frustration. Will this be true on a microcomputer?

Another facet of student interaction involved the question of age of the subjects. In the past, cost and time-sharing on a large computer system limited computer involvement to a great extent to high school level or older students. Now that reduced cost has made the microcomputer more readily available, these small, "personal" computers are being found at all grade levels. Junior high school or middle school age seemed an ideal level to explore the possibilities of microcomputer uses. One reason was the increasing emphasis on exposing this age student to a variety of academic, vocational and leisure content, tools and techniques (Haertel, 1978; "The Education of Youth ...," 1976). A developmental argument in favor of this early adolescent age is that higher level thinking processes can begin to be explored and utilized (Inhelder and Piaget, 1958).

The speed, accuracy, memory and instant feedback capabilities of microcomputers has provided a means for representing more complex processes in order to help students discover relationships (Banet, 1978). Larsen (1979) has found computer programming to be an exciting way of teaching thinking skills and problem-solving. Doerr (1979) maintained that "The computer-aided solution of a problem necessitates a thorough analysis of the problem and a very careful choice of a sequence of steps to arrive at a solution, not to mention the global evaluation of results to see if they are reasonable." From this aspect, microcomputers would be a compatible tool for developing and strengthening the skills of problem-solving.

## The Problem and Its Setting

### A Restatement of the Problem

Science and environmental educators should seek ways of developing relevant problem-solving skills utilizing not only established effective educational methods, but also exploring the utilization of new technological tools. An important first step in tapping one of the newest in available technology is the establishment of baseline data regarding the use of the microcomputer as an unique, but untried, aid in the training and successful development of problem-solving skills.

### The Purpose

The purpose of this thesis was to study early adolescent use of selected problem-solving skills using microcomputers. The study examined two major areas:

1. Evaluating the characteristics, interactions, skill strategies, and achievement of junior high school students as they interacted with a microcomputer in three problem-solving sessions; and,
2. Determining the effectiveness of three newly developed and adapted microcomputer programs in problem-solving

and a fourth program in specific skill training in organizing data.

The specific purposes of this study were:

1. To determine the trends and patterns of student interaction with complex problems on a microcomputer,
2. To determine the extent to which a microcomputer may be used to study selected skills in problem-solving,
3. To determine the relationship of groups who participate in a training session to organize data (matrix training) and groups who do not participate in such a session with (a) their tendency to use a matrix strategy and (b) their relative facility in solving the given problem,
4. To determine the pattern of relationship between the size of the group and the ability to solve the given problems,
5. To determine the relationshp of the variation in complexity of the three microcomputer programs to the problem-solving difficulty, and
6. To determine the relationship of the time between problems attempted and the ability to solve the problems.

## The Research Hypotheses

Hypothesis A: There are unique motivational and interactive trends and patterns which occur when adolescents interact with a microcomputer in their attempt to solve complex problems.

Hypothesis B: As each successive problem is solved students will improve their skill in problem-solving by decreasing the time required to reach a correct solution.

Hypothesis C: The groups who participate in a training session to organize data into a matrix will use the matrix strategy more than groups without the training.

Hypothesis D: The groups who use the matrix strategy successfully will require less time for a correct solution than students who do not use the strategy.

Hypothesis E: There is a curvilinear relationship between the number of students on a team and the time required to reach a correct solution.

Hypothesis F: There is a curvilinear relationship between the number of students in the group and the achievement of a correct solution.

Hypothesis G: There is no significant difference in the difficulty of the three microcomputer programs when presented in random order.

Hypothesis H: Students who attempt to solve programs on three consecutive days will show greater achievement than those groups who attempt to solve programs on a once-a-week basis.

## The Delimitations

This study included 55 volunteer students from study hall classes, 6 volunteers from a gifted program, and 5 volunteers from academic classes. Because of the amount of time required for each research session, it was not feasible to request the withdrawal of this age student from academic classes, however, volunteers were accepted. The sample studied can therefore not be considered a random sample. As study hall students may not have included those students in special areas as band, chorus, and student aides, the sample may not have been representative of the entire student population.

This study cannot be used to make inferences beyond the population of seventh and eighth grade students studied.

This study did not include the utilization of all the problem-solving skills listed in the Stapp and Cox problem-solving model.

This study cannot be used to make inferences concerning the transferability of skills to an action phase of community problem-solving.

This study cannot be used to make inferences concerning the transferability of skills to technological tools of learning other than a microcomputer.

This study cannot be used to exemplify an example of the pedagogical technique of computer-assisted instruction (CAI) in which a student interacts with an instructional stimuli at a computer terminal, usually on a one-to-one basis, usually involved in drill and practice, tutorial programs, or simulations.

## The Definition of Terms

CAI (Computer-Assisted Instruction): CAI is the interaction of a student at a computer terminal wherein the computer system relays instructional material in some form (a paragraph, a question, a stimulus word). The student responds by typing an answer or a command to continue and the system further responds with additional instructional stimuli, which may be some function of the student's previous output (Thomas, 1979).

Matrix: For the purpose of this study, a matrix refers to an array of informational data in rows and columns which show complex relationships in chart form.

Microcomputer: A microcomputer is a general-purpose computer that is small, self-contained, and inexpensive (basic units generally less than $1,000). It has a smaller word size (8 bits), less memory than the standard system, and a reduced capability for side equipment (Doerr, 1979).

Microcomputer Program: A microcomputer program is a sequence of instructions to be stored in the computer's memory.

Problem-Solving: For the purposes of this study, problem-solving refers to a series of developmental process skills which lead from the recognition of a problem to the implementation of a plan of action (Stapp and Cox, 1979). Of the ten steps in this series, only five will be the focus for this study.

1. Recognize the problem,
2. Define the problem,
3. Listen with comprehension,
4. Collect information,
5. Organize information,
6. Analyze information,
7. Generate alternative solutions,
8. Develop a plan of action,
9. Implement a plan of action, and
10. Evaluate the plan of action.

Focus
for
Study

## The Significance of the Study

Throughout the history of science education, it has been recognized that the ability to solve problems is a desirable skill to transmit to students. During the past two decades, science educators have placed a major focus on the development of process skills--skills needed in the solving of a variety of kinds of problems. In the past decade, a heightened sense of public awareness of serious environmental and societal problems has brought a new urgency to the need for a literate, concerned, skilled citizenry throughout the world.

New technology has provided an educational tool, the microcomputer, which shows promise of having unique capabilities of aiding in the creative development of desirable process and/or problem-solving skills. This is a new technology that, if tested, can contribute significantly to teaching strategies, not only in science education, but any discipline or interdisciplinary area where problem-solving and/or student interaction skills are desirable. This technology has been limited to the developed countries in Western Europe, Japan and North America. As this technology becomes available to the 100 or more developing countries, research now conducted can be shared to contribute to the educational process.

Computer instruction in the past has been limited to time-sharing on large, usually distant computer systems where there is no visual display. Such instruction is costly and usually restricted to high school and college students for computer-assisted instruction.

The microcomputer is new and relatively untried educationally and many claims are made on its behalf, both positively and negatively. A search of the available literature revealed that no published research has been reported which gives basic data about the effect of microcomputers in educational settings.

This study can be useful to educational teaching and administrative staff who are considering the introduction and utilization of microcomputers in the public schools at the junior high school level. Direction may also be provided to the developers of microcomputer programs. Also direction may be given to further research efforts in microcomputer contributions to modern education.

## Summary

Science educators place a major focus on the development of a scientifically literate citizen. Environmental educators place a major focus on the development of an environmentally literate world population. While many science educators seek to accomplish their goals within a discipline, environmental educators, in the broadest sense of that term, seek to span several disciplines to develop knowledgeable, motivated, committed citizens who have skills to work toward the solution of societal problems.

Although educators from many disciplines agree that "problem-solving" abilities are desirable and necessary for literate citizens, there is no one definition or series of steps that is universally accepted.

A personally-oriented, active, community problem-solving strategy developed by Stapp and Cox (1979) described a ten-step process which has been recognized as educationally viable. This strategy appears to incorporate most of the steps and sequences described by other educators and theorists, but emphasizes a sequential process which leads to active community problem-solving. It is this Stapp and Cox problem-solving model which was used as the basis for this study.

One way to develop this desirable literate citizenry, skilled in problem-solving, is for schools to provide a diversity of experiences using a variety of materials including a promising technological tool, the microcomputer.

Computers of all sizes pervade our daily lives, but education has lagged far behind business, industry and the general public in utilizing this versatile technological tool. With the advent of the low-cost, general-purpose microcomputer, educators have begun to explore the possible applications to instruction, management and research.

Good commercial programs for the microcomuters have been hard to find and have limited applications. Teachers need to learn to be creative enough to adapt existing programs or write their own to fully utilize the capabilities of the microcomputer in their classrooms.

Early exploration and limited research have indicated that students on a microcomputer are motivated far beyond that of ordinary instructional techniques.

Questions arose concerning optimal interactive methods, size of the group (individual versus group), and grade level applications. Baseline data will contribute to a growing pool of knowledge about the use of this new tool.

Microcomputers have offered this study a technical method of presenting complex material that can challenge the thinking and problem-solving skills. Although it is within the capabilities of the microcomputer to store and run a program complex enough to involve all the steps in the Stapp and Cox problem-solving process, this study utilized logical reasoning programs which focused only on five of the ten steps in order to establish some baseline data from which other studies may evolve. These problem-solving steps are:

1. Recognize the problem,
2. Define the problem,
3. Listen with comprehension,
4. Collect information,
5. Organize information,
6. Analyze information,
7. Generate alternative solutions,
8. Develop a plan of action,
9. Implement a plan of action, and
10. Evaluate the plan of action.

Focus
for
Study

The problem addressed in the study described a need for educators to explore the utilization of new technological tools, specifically the microcomputer, to aid in the development of problem-solving skills.

The purpose of the study was to establish baseline data concerning the development and utilization of three original problem-solving programs on a microcomputer with early adolescents, the development and use of an interactive microcomputer training session in the skill of organizing data, and the evaluation, statistically and anecdotally, of the characteristics and relationships of those interactions of adolescents with each other and with a microcomputer.

Research hypotheses were developed to evaluate the effect on the improvement of problem-solving skills by using observable variables of:

1. The length of time needed to solve each program,
2. The use and effects of a matrix strategy to organize data in each program,
3. The number of students on a team,
4. The relative difficulty of each program used,
5. The frequency of research sessions, and
6. The number of programs solved.

The delimitations stated that:

1. The study sample cannot be described as random,
2. Only five of the ten Stapp and Cox problem-solving processes were utilized,
3. Inferences cannot be made beyond:
    a. A population of seventh and eighth grade students, or
    b. Technological tools other than a microcomputer,
4. Inferences cannot be made concerning transferability of skills to community action plans, and
5. The study does not exemplify an example of the pedagogical technique of CAI (Computer-Assisted Instruction).

This study was significant in that baseline data can contribute to teaching strategies where advanced technological aids are available. Research data will be available in an area void of published research to date; teachers and administrators may glean direction from study results; and microcomputer programmers may derive new ideas and possibilities for creative new programs in the future.

## Chapter Outline of the Study Presentation

Chapter I has introduced the study by (1) developing the background and need by means of a literature review in the two areas of problem-solving and the emergence of a new technological tool, the microcomputer, and (2) the presentation of the study problem and its setting.

Chapter II reviews relevant research studies pertaining to problem-solving, computers, microcomputers, and group interaction.

Chapter III presents the methodology of the study and a descriptive analysis of the sites, instruments, and the subjects. Research Hypothesis A is discussed in this chapter since the analysis is composed of conclusions based on anecdotal observations made during the research sessions and is therefore descriptive.

Chapter IV presents the research design and the statistical data and analyses of the null hypotheses B through H. Two questions of true interest are considered, analyzed and discussed: the changes in choice of clue category and a search for possible interactions of variables that may have been overlooked. A final test of relationships attempted to analyze the entire battery of variables, treatment and observations to summarize and cross check the significant influences of the study.

Chapter V presents the summary of the study, conclusions drawn from both the descriptive and statistical analyses, and recommendations for further study.

# CHAPTER II

# REVIEW OF RELATED RESEARCH

## Introduction

This chapter reviews relevant research pertaining to microcomputers, problem-solving, CAI on computers, and group interaction.

A search of the literature has revealed no published research relating problem-solving and learning for adolescents using microcomputers. One unpublished paper will be reviewed which reported research begun in 1979 at The University of Michigan exploring applications of scientific and mathematical processes by adolescents on microcomputers.

Although it is not the purpose of this study to detail the complex interactions of a variety of "problem-solving" processes, a study by Morris (1970) will be discussed which has provided a useful background in a study of group problem-solving.

The few studies that have been found related to group instruction on large computer systems are, with the exception of one, all at the college level and involve CAI (computer-assisted instruction) associated with course content. Three of these merit discussion in this review.

Three research studies that have been very helpful concern small group interaction. Again, most of these studies have been with college level or adult subjects. One study (Hare, 1952) was found that was done with adolescents.

## Adolescents on Microcomputers

An unpublished study by Berger, Newman, and Cox (1980) investigated the effect of the amount of visual information available while solving a problem of estimation. This study was a part of a microcomputer-based inquiry into scientific and mathematical processes, and the use and training of problem-solving strategies among children, adolescents and adults.

In this investigation data were gathered from ten adolescents ranging in age from twelve through fourteen. Their academic abilities spanned a wide normal range. Their task was to estimate the height of a simulated balloon on a "wall" with varying amounts of visual information to aid their deliberations.

Results suggest that skill in estimation of distance might be achieved with minimal training using a microcomputer simulation and such training may help students develop some sort of quantitative intuition.

The implications of the Berger, et al. (1980) research for this study are that (1) microcomputers can be used to gather data on conditions under which students increase skills, (2) the use of information directly available to students may help to assist in increasing the ability to improve problem-solving, and (3) helping students to "see" the gains they make, may have more positive effects in self-image than many traditional reward systems available in classrooms today.

In this study (1) the microcomputer was used to collect data,

(2) students could at any time call for or recall information, and (3) students could at any time check to see if their solution or part solution was correct.

## Problem-Solving

As discussed in Chapter I, there has been no universal agreement on the specific steps involved in the problem-solving process. However, some of the literature indicated that problem-solving begins with a problem either defined or to be defined, data is collected and processed and decisions must be made on solutions which can then be evaluated and implemented. The study by Morris (1970) addressed the question of whether problem-solving groups change the nature of their activities as they progress toward problem solution. In order to proceed with the study, Morris needed to establish the problem-solving categories which he used. He reviewed Wallas' (1926) four steps, Dewey's (1910) six steps and chose to adapt the Heyn's (1948) problem-solving categories, or "acts," into a list of 17 categories.

The subjects for the Morris (1970) study were 162 Army and Navy ROTC cadets and midshipmen at the University of Illinois assembled in 54 three-man groups. Two tasks were given with topics related to the Army and Navy. One task was a negotiations task and the other was a group creativity task. The focus was entirely on the task oriented processes of problem-solving using the 17 categories based on Heyn's work. An "act" was defined as a simple sentence and each act was assigned to one of the 17 categories.

Tape transcripts were divided into three eight-minute segments so that task change could be noted.

The results of this study clearly indicated that the group problem-solving process was not homogeneous over time. The extent to which group members engaged in planning, proposing solutions, clarifying and defending statements and repeating previous comments changed significantly as the group progresses in its work. The number of acts of planning were greatest in the first period of work and numbers of solutions proposed were greatest in the later stages. There was a dramatic rise in repetition in the last eight minutes suggesting that repetition plays an important function in the final stages of problem-solving.

One of the capabilities of the microcomputer is to record the order and clue number of the students' choice in problem-solving programs designed for the author's research study. It will be possible to analyze the amount of repetition used by each group and where in the program it occurs. This could lead to some interesting observations in the anecdotal portion of the study.

## Adolescents in CAI

In the only published research study found relating to adolescents and computers, Knight and Dunkleberger (1977) analyzed the influence of computer-managed, self-paced instruction on the science attitudes of students. Their subjects were 127 ninth graders in the chemistry and physics classes in a suburban high school. Only students in the lower half of the class were studied. Of the 94 in the final analysis, 46 were in the computer group.

The unique aspect of this study was that the students were evaluated over a period of an entire school year. Results showed that achievement was the same in both the experimental and control groups at the end of the year. An attitude survey indicated increased positive attitudes toward science in the computer group.

Application of the Knight and Dunkleberger research to this study is limited in that it dealt only with the attitudes and achievement when individuals interacted with printouts on a remote terminal of a large computer system. But their study does point toward a consistent level of interest and motivation over a longer period of time.

## Group Dynamics and Attitudes in CAI

Studies by Brown and Gilman (1969), Schwartz and Long (1967), and Mathis, Smith, and Hansen (1970) supported the view that attitudes toward instruction are improved when subjects interact with a computer as opposed to such conventional methods as programmed instruction frames, self-study, or reading-only. However Hall (1971) cautioned that "adequate empirical data will not be available until students have been exposed to CAI over a number of years in varying subject matter areas."

In 1972 Gerrell investigated the extent to which computer-assisted instruction (CAI) and knowledge of group dynamics can overcome the serious instructional problems of large introductory lecture courses. Students were divided into three sections. Students in one section received the CAI as individual students; students in another section studied in small groups and received the CAI as a group; the third section served as the control group. Academic achievement, attitudinal development, and the sociometry of the students in the test sections were studied. It was found that the students preferred small group instruction. Also it was found that the students studying in small groups sometimes achieved academic results which were superior to the control group; but occasionally the small group produced significantly inferior results. When this happened, the group also demonstrated a significant deterioration in social structure. Gerrell concluded that a combination of CAI and careful attention to group dynamics can be an effective way to reduce costs and solve the problems of large group instruction.

Also concerned with the high cost of individual interaction with shared-time teletype terminals of a large computer system, Cartwright and Cohen (1977) investigated the learnings and attitudes of the individual while working in a group on a CAI program. A specifically designed,group-CAI program permitted the entry and evaluation of responses from each group member.

This study took place at the college level utilizing students from the Introductory Educational Psychology classes. There were three treatment groups working in groups of three who participated in three lessons in one week's time. Five days after the last lesson, each individual took a 30-item attitude test. Results showed that (1) there was no significant difference in mean individual learning scores in the three groups, (2) the experimental group took significantly longer, and (3) individuals working alone made significantly more errors than individuals working together in teams.

These two studies suggest that there is a positive effect when students work together in groups on a computer but includes a caution to carefully consider the group dynamics involved. This may be particularily pertinent at the junior high school level where peer relationships are vitally important to the individual student.

## Group Interaction Studies

The areas of psychology and sociology have revealed a considerable number of studies concerning group size as it relates to group interaction. Hare's (1952) basic premise was that size is a significant determining factor in group interaction. To test this hypothesis, 150 Boy Scouts in a summer camp took part in small discussion groups. The subjects were divided into nine groups of five boys and nine groups of twelve boys. The subjects were given a situation and asked to rate a list of equipment. Discussion followed, and subjects were asked to again rate the equipment list. The amount of consensus of individual with group was used to measure the change of opinion thus to reveal characteristics of the nature of interaction during discussion.

Results of this study indicated that in larger groups members tended not to participate as frequently and also larger groups tended to break into factions. The implications of the Hare research for this study would indicate that smaller groups would increase interaction and result in the group working together more effectively. When that same group is interacting with a visual display on the 5½ by 7½ inch screen of a microcomputer, size of group may indeed be a critical factor.

Bales and Borgatta (1955) also reported the effects of group size on the social interaction of members within the group. The subjects were male students drawn from the university employment office and paid for their time. There were a total of 108 students and 36 sessions. Groups of each size, two through seven, were observed. Their task was the discussion of a human relations case in which they were to assemble the information to discuss why the people involved were behaving the way they did, and to decide what the recommendation for solution would be. Each group met for four sessions and were given a similar, but different situation each session. Data consisted of the raw number of acts recorded in each of twelve categories, called a raw profile, per member, per session. Raw profile was converted to a percentage profile.

Results of the study indicated that:

1. Talking time available for each person decreased as the group size increases,
2. Larger groups could divide into sub-groups (supporting Hare's conclusions),
3. As group size increased, each member had more relationships to maintain, and less time to do so,

4. When time was at a premium members may have felt under pressure to take the direct approach,
5. Establishing group membership applied about equally strongly to all groups,
6. As size of group increased, tensions decreased, since there were less participation demands on each individual, and
7. There was a uniqueness about two-man groups: (a) there was high tension, (b) there was a low rate for showing disagreement and antagonism, (c) asking for orientation was uniquely high, and (d) it was impossible to form a majority.

In another study of group size, Taylor and Faust (1952) used a game of twenty questions as a test of problem-solving on individuals and groups of two and four. A total of 105 students from an elementary course in psychology were assigned to work in 15 groups of two, and 15 groups of four, and 15 individually. Each individual and group was given four problems a day for five days.

Results indicated that group performance excelled that of individuals in terms of numbers of questions, number of failures and time per problem. More groups of four failed to reach a solution than other groups or individuals. In man-minutes per problem to solution, individuals were highest, but groups of two were higher than groups of four. There were only negligible differences in groups of two and four suggesting to the researchers that the optimal size is not larger than four. But there were no data to prove or disprove this.

Studies by Zimet and Schneider (1969) and Barnlund (1959) supported the findings of the three studies detailed above. Barnlund noted that in some instances, groups of the least competent subjects were, through discussion, able to surpass the decisions made by the most talented person working alone.

This review of the research as related to group size would indicate that not only would smaller groups work more effectively together, but that group decisions are often superior to individual decisions. In this review, groups from two through twelve were discussed. It would seem reasonable to establish the effective group size for the author's study at two or three with a group of five and an individual alone as the comparative upper and lower limits.

## Summary

Interaction by adolescents with a microcomputer is a new research field. Only one research study has been found in this specific area. To find more research which will shed light on various aspects of student problem-solving interactions in this field, it has been necessary to glean suggestions and directions from other age level studies and discipline and professional areas.

In the Berger, et al. (1980) study on adolescents using microcomputers the implications directly applicable to this study indicated that:

1. Microcomputers can be used to gather data on conditions under which students increase skills,

2. The use of information directly available to students may help to assist in increasing the ability to improve problem-solving, and
3. "Seeing" the gains made may have more positive effects in student self-image than traditional reward systems.

Recognizing the limitations of studies from related research from other levels and fields, general theories adaptable to the author's specific topic area are as follows:

1. Attitudes become more positive when students work with computers rather than conventional types of instruction,
2. Achievement does not differ significantly when computer learning is compared to conventional learning modes,
3. Students prefer small group instruction to individual study,
4. The researcher must consider the dynamics of the group when assigning interactive groups,
5. Smaller groups increase interaction and work together more effectively,
6. As the size of the group increases: (a) talking time decreases, (b) sub-groups form, (c) there are more relationships to maintain, and (d) tensions decrease,
7. There is a uniqueness about a two-person group that is desirable for group work,
8. In some instances, a group of least-competent subjects were able to surpass the decisions of a most talented person working alone,

9. There is no common description of problem solving steps or stages, and
10. The interactions in the group problem-solving process are not homogeneous over time.

The final challenge for this study was given by Whitfield (1951):

> For the study of problem-solving it is desirable that the problem chosen should be such that a measure of stimulus difficulty can be made, and that changes in stimulus difficulty in the process of solution can also be measured. The phenomenal difficulty should be measurable from the behavior of individuals. Further, the problems chosen ought to be such that qualitative observations, which may hint at the modes of solution attempted or the mental processes involved, should be capable of record.

## CHAPTER III

## METHODS AND DESCRIPTIVE ANALYSES

### Introduction

This chapter presents the methods and descriptive analyses of the study. The procedure, instruments and sites are described and the characteristics of the student subjects are analyzed by means of graphs, distribution tables, correlations and discussion. A subjective analysis of anecdotal observations focus on subject reaction to the microcomputer, solving a complex problem, group seating, group interactions, and the relationships between ability levels and group interaction. A transcript of a taped conversation during a research session is provided to highlight the intricacies of the problem-solving process in this study.

### The Procedure

A total of eighty-seven volunteer seventh and eighth grade students from four junior high schools in the school districts of Farmington and Clarenceville in suburban metropolitan Detroit were recruited to solve these problems of logic and reasoning requiring the use of problem-solving skills. These problems were presented on a Commodore PET microcomputer. Of these eighty-seven participants, sixty-six completed all three sessions in intact groups.

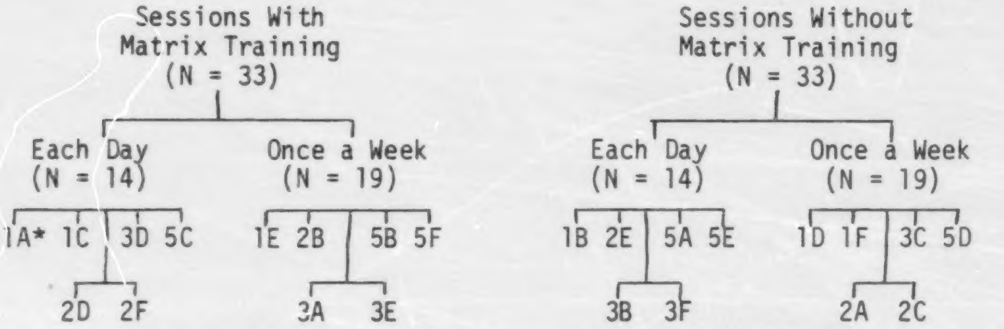
Students were randomly assigned, as available (if homework or makeup work did not take priority), to work individually or in groups of two, three, or five. Each individual and group met for three sessions. Each session lasted for the entire class period of fifty minutes. Extra time following solution of the research problem was used in microcomputer exploration and/or microcomputer games. All sessions took place during the last two periods of the school day, Monday through Friday, for a period of fourteen weeks.

A twenty-nine item Cognitive Inventory, created by the author, surveyed the knowledge of the specific background information which the subjects must use to find the solution for the three problem-solving programs (see Appendix A). Prior to meeting in the first session, the subjects as a group were asked to respond to the Cognitive Inventory survey. At this time identification numbers were established for each subject.

Three original interactive problem-solving microcomputer programs were constructed by the author for the purposes of this study. The content of these programs was drawn from the discipline areas of life science and social studies, and the interdisciplinary area of environmental education (see Appendices B through D).

An interactive matrix training program was created by the author to determine if controlled interactive training would transfer to and facilitate solution of the three problem-solving programs (see Appendix E).

In each of three sessions each individual and group was presented with one of the three problem-solving programs. Half the subjects were presented with the short, five to ten minute matrix training program preceeding the second session. Half the subjects received no special session. Half the subjects worked on programs on three consecutive days, one each day; half worked on the programs once a week for three weeks, one each day. This scheduling is outlined in Figure 2.


Sessions With
Matrix Training
(N = 33)
Each Day
(N = 14)
1A* 1C 3D 5C
2D 2F
Once a Week
(N = 19)
1E 2B 5B 5F
3A 3E
Sessions Without
Matrix Training
(N = 33)
Each Day
(N = 14)
1B 2E 5A 5E
3B 3F
Once a Week
(N = 19)
1D 1F 3C 5D
2A 2C

*A, B, C ... refers to program order of presentation (see Figure 3).
1, 2, 3, 5 refers to number of subjects in the group.

Figure 2. Schematic Outline of Research Cell Sizes With Subject N

All possible combination of presentation order of the problem-solving programs were utilized for all group sizes (see Figure 3).

Research sessions were scheduled as much as possible on Monday through Thursday. Because of vacation and inservice days, some schedule shifting necessarily took place. For this reason six sessions were scheduled on Fridays. During the eighth week an early dismissal for teacher inservice was announced only one day ahead, so two sessions already scheduled were shifted to one day later.

One day during the ninth week when the author arrived at the third school for scheduled sessions, she was informed that it was

| Student N | Session N | Group Size | Presentation Order | Time Lapse | Matrix Training |
|---|---|---|---|---|---|
| 6 | 18 | 1 | A* | Every day | yes |
| | | 1 | B | E.D. | no |
| | | 1 | C | E.D. | yes |
| | | 1 | D | Once a week | no |
| | | 1 | E | O.W. | yes |
| | | 1 | F | O.W. | no |
| 12 | 18 | 2 | F | E.D. | yes |
| | | 2 | E | E.D. | no |
| | | 2 | D | E.D. | yes |
| | | 2 | C | O.W. | no |
| | | 2 | B | O.W. | yes |
| | | 2 | A | O.W. | no |
| 18 | 18 | 3 | B | E.D. | no |
| | | 3 | D | E.D. | yes |
| | | 3 | F | E.D. | no |
| | | 3 | A | O.W. | yes |
| | | 3 | C | O.W. | no |
| | | 3 | E | O.W. | yes |
| 30 | 18 | 5 | A | E.D. | no |
| | | 5 | C | E.D. | yes |
| | | 5 | E | E.D. | no |
| | | 5 | B | O.W. | yes |
| | | 5 | D | O.W. | no |
| | | 5 | F | O.W. | yes |
| 66 | 72 | | | | |
| Totals | | | | | |

*Code for Presentation Order:

A = "Energy at Home," "Vertebrate Pets," "Global Travelers"
B = "Energy at Home," "Global Travelers," "Vertebrate Pets"
C = "Vertebrate Pets," "Energy at Home," "Global Travelers"
D = "Vertebrate Pets," "Global Travelers," "Energy at Home"
E = "Global Travelers," "Energy at Home," "Vertebrate Pets"
F = "Global Travelers," "Vertebrate Pets," "Energy at Home"

Figure 3. Variables Within the Research Sessions

"backwards day" which meant the class scheduling was reversed for the day; afternoon study halls were in the morning. It was then necessary to have subjects excused from their afternoon classes to participate in the research that day. In all cases in all buildings school personnel were interested and very cooperative.

Research sessions were regarded as complete when all subjects who began the first session were present to complete all three sessions. Individual subjects were not replaced within a group once a session series was begun. When one student was absent from a group session, that group was withdrawn from the research data and another group was formed to begin at a later date. In most cases, the author encouraged the partial groups to continue to meet as scheduled and finish the problem-solving series. None declined. A total of five groups were withdrawn because of the absence of one subject in either the second or third session. A complete time schedule of research sessions is outlined in Appendix J.

Data were collected in five ways:

1. Grade point averages and verbal reasoning or total language test scores were collected from school records by student ID,
2. Raw scores were collected on the Cognitive Inventory for analysis by totals,
3. Statistical data were gathered on the microcomputer as each program was played and stored on a cassette data tape for later retrieval by the researcher. Data were collected on:

a. Student ID
b. Age
c. Grade
d. Sex
e. Number of programs played
f. Whether solution was reached
g. Total time to solution (or give up)
h. Clue order by category and number
i. How many times each clue was asked for
j. Total number of clues asked for.

4. The working paper of each individual and group was collected to determine the use of a matrix strategy to solve the problem, and
5. Anecdotal notes and audio tapes of student conversations were gathered by the author during each session. These were especially useful for cross-referencing on those few occasions when there was electrical interference or data overload resulting in loss of data saved in the computer memory. It was possible to reconstruct all data information.

## The Sites

Seventh and eighth grade subjects were recruited from three junior high schools in the Farmington Public Schools in the cities of Farmington and Farmington Hills and from the junior high school in the Clarenceville Public Schools in the cities of Farmington Hills and Livonia in Michigan.

The cities of Farmington, Farmington Hills, and Livonia from which the sample of subjects was drawn are neighboring suburbs of metropolitan Detroit containing a wide range of mostly white socioeconomic families. Two of the schools where the study took place were mostly in the upper middle class of this range; two of the schools were mostly in the middle or lower economic class. The Farmington School System had over 12,000 students and the junior high schools contained grades seven through nine. The Clarenceville School District had just under 3,000 students and the junior high school contained grades seven and eight.

The work space for the research sessions varied from building to building with available space. An important location consideration in each building was proximity to parking areas since the microcomputer had to be carried in from the car and out again each day.

In the first school, eighteen sessions were held in one of the two conference rooms in the principal's office complex. There were no windows and no outside distractions.

In the second school, thirty-six sessions were held in a conference room on one side of the media center which was glassed in on all four sides. Two of the half-window walls were easily accessible to observers from the media center. Also the only pencil sharpener in the media center was on the door frame of the conference room. In spite of this "fishbowl" effect, there was a minimum of distractions.

In the third school, twenty-nine sessions were held in the teacher's dining room; a room with no windows. There were no outside distractions.

In the fourth school, three sessions were held in an empty classroom. There were no outside distractions.

Seating arrangements were standardized for similar sized groups. The author felt that since the microcomputer display screen is only 5½ by 7½ inches that seating could be an important factor in group interaction, particularly in the larger sized groups. The chair for the individual was centered in front of the screen. For the groups of two and three, the chairs were equally centered in one row. The group of five had three chairs placed in a front row and two chairs centered in a second row.

Paper and pencil was on the table when groups arrived. An audio tape recorder was placed next to the microcomputer. Its use was explained and most groups ignored it.

## The Instruments

### The Cognitive Inventory

The Cognitive Inventory is a 29 item survey which analyzed the background information which the subjects needed to use to help solve the three problem-solving programs. This Inventory included questions concerning:

1. Knowledge of the characteristics of the five groups of vertebrates (science topic),
2. Knowledge of foreign travel, geography and culture in three familiar foreign countries (social studies topic), and
3. Knowledge of facts concerning the current energy situation (environmental education topic) (see Appendix A).

## The Problem-Solving Programs

Three original interactive problem-solving programs were constructed by the author for the purposes of this study. The content of these programs was drawn from the discipline areas of life science and social studies, and the interdisciplinary area of environmental education.

Paper and pencil forms of these exercises have been used repeatedly with groups from junior high age through adults. In the experience of the author, these programs have been effective in developing skills in group process and problem-solving (see Pilot Studies in Appendices H and I).

The three programs are described as follows:

1. "Vertebrate Pets" is a microcomputer program of logical thinking requiring the player(s) to utilize 20 clues to develop a complex solution. The problem to be solved concerns six students and the kind of vertebrate pet each brought to school. Clues give indirect information

requiring that inferences be made. This has a twelve-part solution requiring approximately 15 to 40 minutes. A list of problem, clues, and a printout of the microcomputer program listing are reproduced in Appendix B.

2. "Global Travelers" is a microcomputer program of logical thinking requiring the player(s) to utilize 20 clues to develop a complex solution. The problem to be solved concerns three travelers, the capitol city each visited, and the airline each used. Clues give direct and indirect information requiring that inferences be made. This has a nine-part solution requiring approximately 15 to 40 minutes. A list of problem, clues, and a printout of the microcomputer program listing are reproduced in Appendix C.
3. "Energy at Home" is a microcomputer program of logical thinking requiring the player(s) to utilize 20 clues to develop a complex solution. The problem concerns three individual homes, the fuel each used for heating and the thermostat setting in each home. Clues give direct and indirect information about the current energy situation and require that inferences be made. This has a nine-part solution requiring approximately 15 to 40 minutes. A list of problem, clues, and a printout of the microcomputer program listing are reporduced in Appendix D.

A statistical analysis of the relative difficulty of these three programs is reported in Chapter IV. The texts of these three programs were analyzed for readability using the Bormuth Readability Index. Results are reported in Table 1.

TABLE 1

ANALYSIS OF READABILITY OF FOUR MICROCOMPUTER PROGRAMS USING THE BORMUTH READABILITY INDEX

| Variables | Programs | | | |
|---|---|---|---|---|
| | "Vertebrate Pets" | "Energy At Home" | "Global Travelers" | "Try A Matrix" |
| Words | 527.00 | 620.00 | 579.00 | 427.00 |
| Sentences | 64.00 | 66.00 | 62.00 | 43.00 |
| Letters | 2088.00 | 2673.00 | 2457.00 | 1706.00 |
| Word Length | 3.96 | 4.31 | 4.24 | 3.99 |
| Sentence Length | 8.20 | 9.30 | 9.30 | 9.90 |
| % Words on Dale List | 96.43 | 94.69 | 95.03 | 96.27 |
| Readability Index | 46.40 | 52.80 | 51.90 | 50.70 |
| Grade Level | 3.10 | 4.80 | 4.50 | 4.20 |

An examination of Table 1 indicated that the readability level of all programs adapted for the microcomputer was at or below 4.8 grade level. For seventh and eighth grade subjects there should have been little, if any difficulty with reading comprehension.

## The Matrix Training Program

An interactive training program to aid subjects in organizing data by using a matrix was created by the author to determine if controlled interactive training on a microcomputer would transfer to and facilitate solution of the three problem-solving programs.

In "Try a Matrix," the text of the microcomputer program defined a "matrix," explained its usefulness and led the subject through steps to a twelve part solution. The time required ranged from five to ten minutes. No writing was required. A printout of the microcomputer program listing is reproduced in Appendix E. The text of the program was analyzed for readability using the Bormuth Readability Index. The results are reported in Table 1. An examination of the results in Table 1 indicated that the readability of the matrix training program was at a 4.2 grade level, comparing well with the readability of the three problem-solving programs. There was no problem with reading comprehension.

## The Data Retrieval Program

The three microcomputer programs used for the research sessions of this study included steps which saved data entered by the subjects during each problem-solving session (ID, age, grade, date, number of programs played, number of clues asked for by order and totals, time to solution, and whether the problem was solved or not). At the end of each session this information, internally stored in the microcomputer, was recorded on a separate cassette tape. The data retrieval program would retrieve any or all of this information at any time that the researcher wished to use or analyze it. The printout of the microcomputer program listing is reproduced in Appendix F.

## The Subjects

Fifty-five seventh and eighth grade students were recruited from study hall classes in three of the four schools. Because of the time required to complete each session, the researcher felt that it was not feasible to request that a large number of students be excused from academic classes. In one school six students from the gifted program requested permission to participate and were subsequently excused from their afternoon classes to attend. In the fourth school there were no afternoon study halls, so five students were recruited from morning science classes and were excused from their afternoon academic classes to attend research sessions.

There were no restricting criteria for participation. Any student could volunteer and all volunteers were accepted until the required number of students was reached.

Of the sixty-six subjects who completed the research sessions, 48 were male and 18 were female (see Figure 4). Twenty-three subjects were twelve years old, 32 were thirteen, and 11 were fourteen years of age (see Figure 5). Forty students were in seventh grade and 26 were in eighth grade (see Figure 6). The age and grade distribution by sex is shown in Table 2.

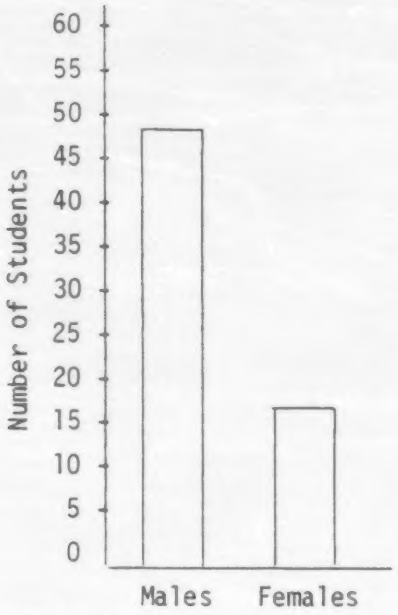


Figure 4. Distribution of Subjects by Sex

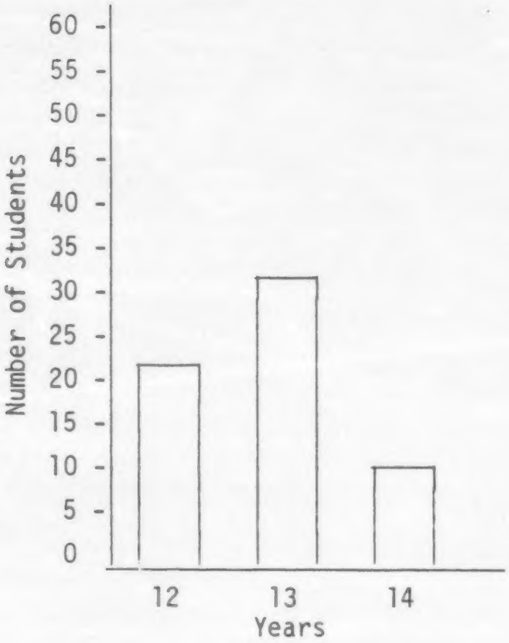


Figure 5. Distribution of Subjects by Age

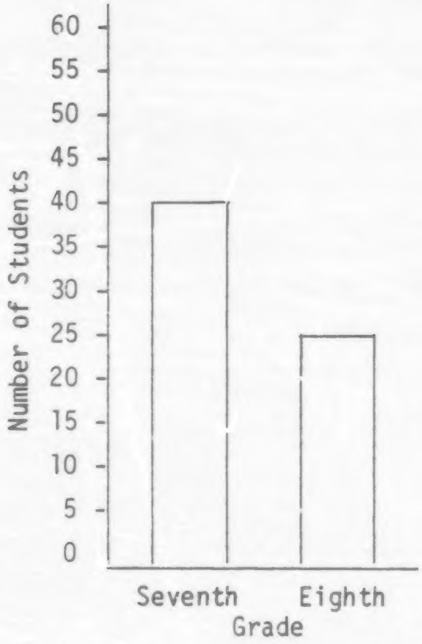


Figure 6. Distribution of Subjects by Grade

## TABLE 2

## AGE AND GRADE DISTRIBUTION BY SEX

| | | Age | | | Grade | |
|---|---|---|---|---|---|---|
| | Total | 12 yrs. | 13 yrs. | 14 yrs. | Seventh | Eighth |
| Males | 48 | 9 | 31 | 8 | 26 | 22 |
| Females | 18 | 14 | 1 | 3 | 14 | 4 |
| Totals | 66 | 23 | 32 | 11 | 40 | 26 |

An analysis of subjects by building indicated that 16 were from building one, 30 from building two, 15 from building three, and five from building four (see Figure 7).

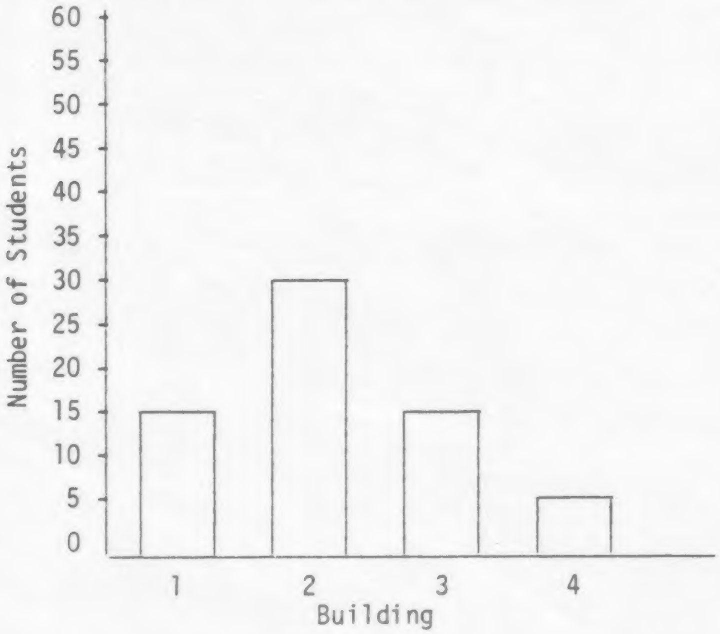


Figure 7. Distribution of Subjects by Building

Independent variable data were gathered on each subject. In the planning stages of this research there was a concern that by recruiting from study hall classes there would not be a full range of subject abilities. The highest and lowest verbal reasoning test scores were attained by study hall students in the first building. There was a full range of percentile scores, 1 to 99, on either the verbal reasoning portion of the Differential Aptitude Test (D.A.T.) or the Cognitive Abilities Test (C.A.T.) or the total language portion of the Iowa battery of tests. It was necessary to use test scores as available in the student records. In all cases the latest test given was used (see Figure 8).

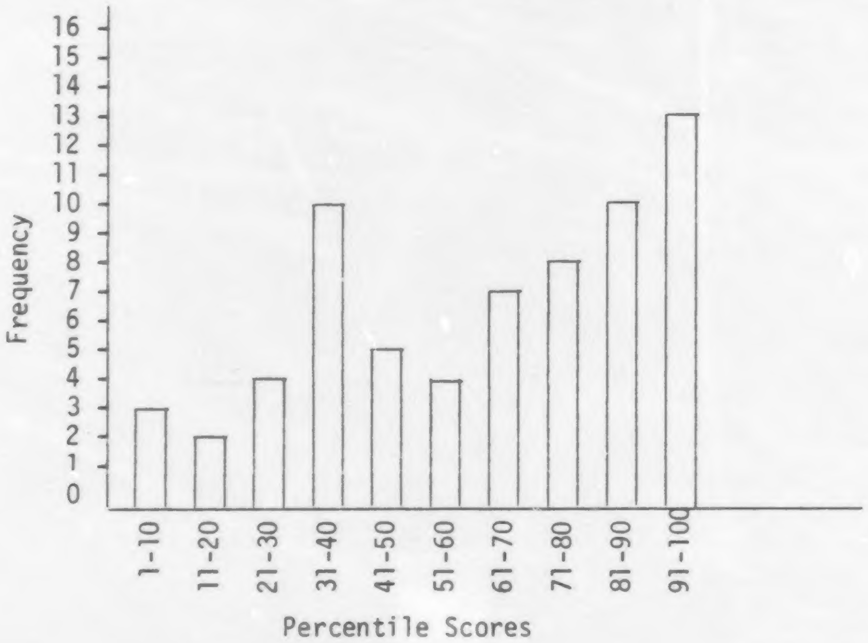


Figure 8. Distribution of Verbal Reasoning (or Total Language) Scores

Current grade averages were calculated from the previous semester of grades in eight academic classes. There was a full range of passing grades. No research subject had a failing average. The distribution could be described as a negatively skewed normal curve indicating a fairly normal distribution of student abilities in the research sample. An analysis of distribution of grade averages by sex indicate similar curves (see Figures 9 through 11).

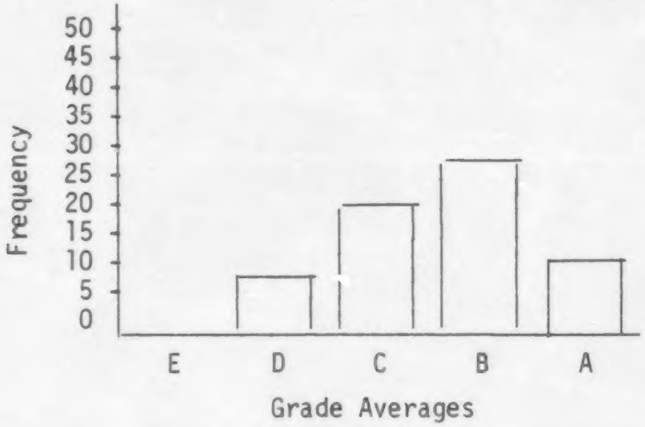


Figure 9. Distribution of Grade Averages of Subjects, N = 66

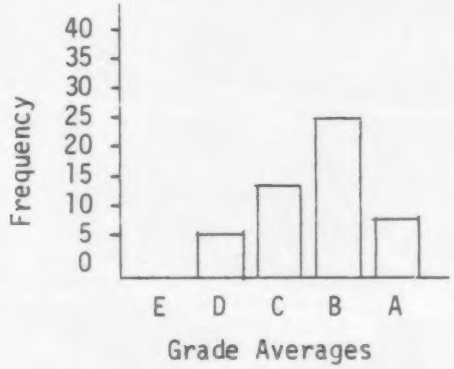


Figure 10. Distribution of Grade Averages of Males, N = 48

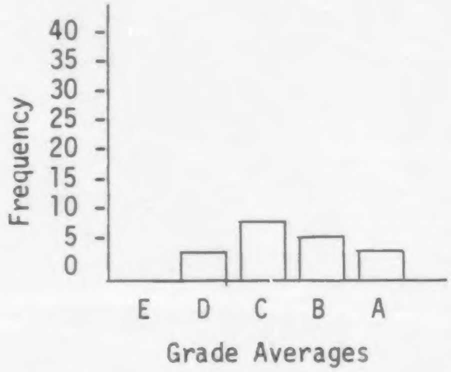


Figure 11. Distribution of Grade Averages of Females, N = 18

Abilities of subjects, as measured by current grade averages, were in most cases quite normally distributed within groups of the same size as indicated in Table 3.

TABLE 3

DISTRIBUTION OF GRADE AVERAGES
WITHIN SIMILAR SIZED GROUPS

| Group Size | Grade Average | | | |
|---|---|---|---|---|
| | D | C | B | A |
| 1 | 1 | 3 | 0 | 2 |
| 2 | 1 | 4 | 5 | 2 |
| 3 | 3 | 5 | 7 | 3 |
| 5 | 3 | 8 | 16 | 3 |
| Totals | 8 | 20 | 28 | 10 |

Although subjects were randomly assigned to groups as time and class were available, it is apparent that the ability distribution happened to be consistent throughout the group sizes. A graphic representation of this relationship between grade average and group size is shown in Figure 12.

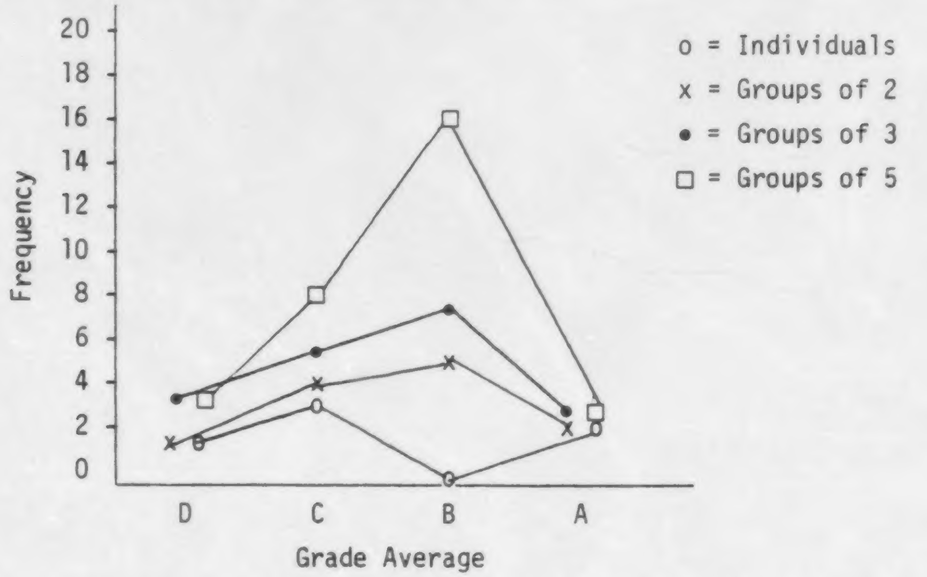


Figure 12. Relationship of Frequencies of Grade Average and Group Size

Of the Cognitive Inventory survey, subjects scored a range of 9 to 31 raw score totals out of a possible 38 (see Figure 13).

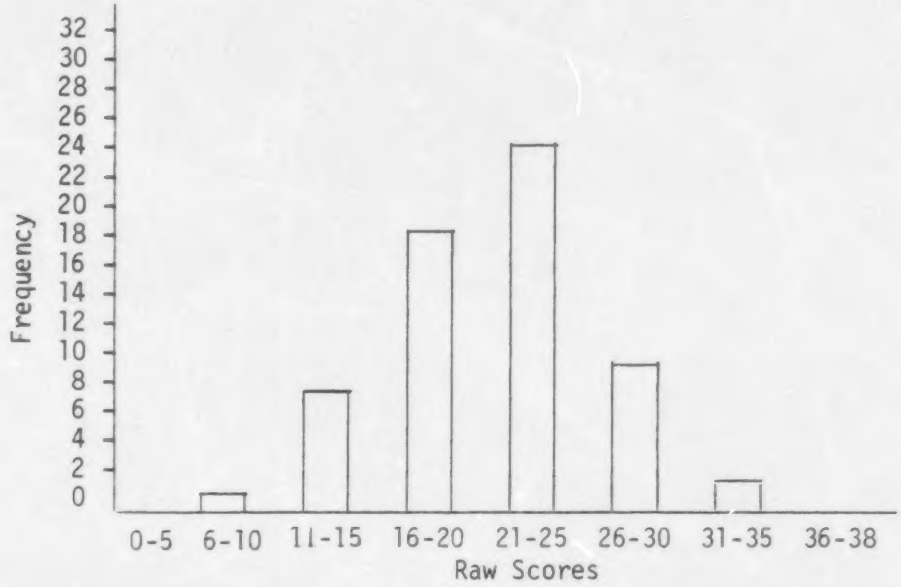


Figure 13. Distribution of Cognitive Inventory Raw Scores, N = 66

An analysis of the amount of computer experience by each subject indicated that 42 of the 66 subjects had never interacted with a computer prior to research sessions; 19 had played some games on a computer; 3 subjects had done some programming and 2 subjects claimed they had done a lot of programming. No student indicated that they had a computer of their own (see Figure 14).

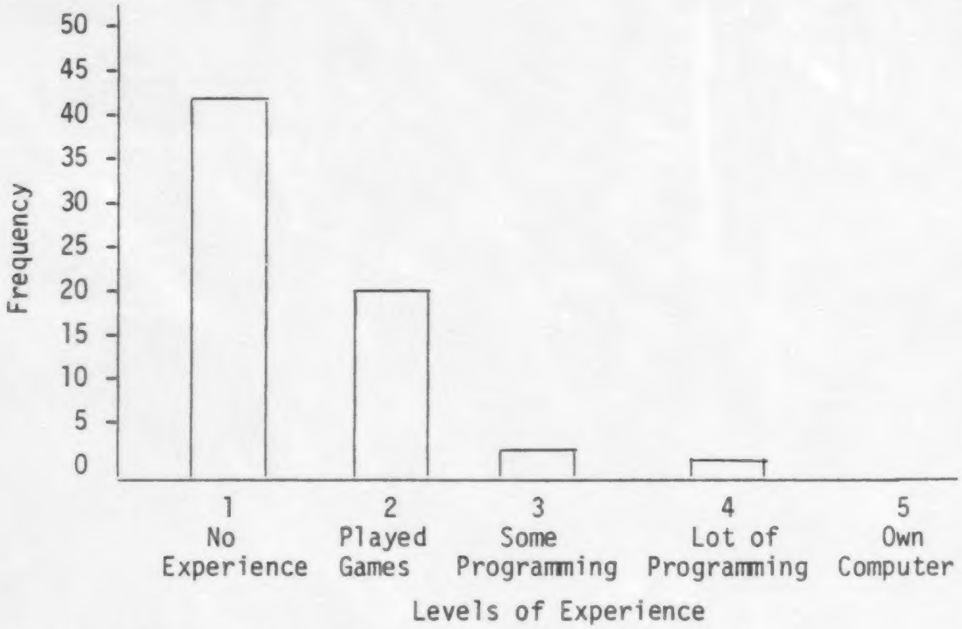


Figure 14. Distribution of Computer Experience of Subjects

The analysis of the four independent variables of verbal reasoning scores, grade average, computer experience and Cognitive Inventory raw score indicated that the sample of subjects contained a full range of abilities and exhibited a normal distribution of achievement. However, experiences differed when microcomputers were involved since 64% had never had access to a computer before. A summary of these four independent variables is reported in Table 4.

TABLE 4

SUMMARY OF FOUR INDEPENDENT VARIABLES:
VERBAL REASONING SCORE, COGNITIVE INVENTORY SCORE,
GRADE AVERAGE, COMPUTER EXPERIENCE, N = 66

| | Mean | Standard Deviation | Range | Possible Score |
|---|---|---|---|---|
| Verbal Reasoning Score | 62.92 | 26.34 | 1-99 | 100 |
| Cognitive Inventory Score | 20.98 | 4.80 | 9-31 | 38 |
| Grade Average | 2.62 | 0.88 | 0-4 | 4 |
| Computer Experience | 1.47 | 0.72 | 1-4 | 5 |

A correlation matrix was constructed to analyze the relationships between the seven discussed independent variables (see Table 5). Moderate correlations were indicated between age and grade (R = .6577), and grade average and the verbal reasoning test (R = .6370). Lesser correlations were found between grade average and the Cognitive Inventory (R = .4658), and the verbal reasoning test scores and the Cognitive Inventory survey scores (R = .4321).

Low correlations were indicated between computer experience and the verbal reasoning test scores (R = .3109) but were not significantly correlated with the other variables: Cognitive Inventory survey, sex, age, grade and grade average. Since there were no computers in the schools at that time, this finding would be inconclusive depending more on socio-economic status and availability of technology than on ability or maturity.

## TABLE 5

## CORRELATION MATRIX OF SEVEN INDEPENDENT VARIABLES

| Variable | 1. Sex | 2. Age | 3. Grade | 5. Grade Average | 6. Computer Experience | 15. Verbal Reasoning Test | 16. Cognitive Inventory Survey |
|---|---|---|---|---|---|---|---|
| 1. Sex | 1.0000 | | | | | | |
| 2. Age | -.3786 | 1.0000 | | | | | |
| 3. Grade | | .6577 | 1.0000 | | | | |
| 5. Grade Average | | -.2643 | -.2716 | 1.0000 | | | |
| 6. Computer Experience | | | | | 1.0000 | | |
| 15. Verbal Reasoning Test | | -.3581 | -.3775 | .6370 | .3109 | 1.0000 | |
| 16. Cognitive Inventory Survey | -.2605 | | | .4658 | | .4321 | 1.0000 |

N = 66 DF = 64 R @ .05 = .241 R @ .01 = .311

## Research Hypothesis A: Anecdotal Observations

In an exploratory study such as this it was virtually impossible to anticipate the full range of interactions, problems, successes, and insights which occur. For this reason the author kept an anecdotal record of events, conversations, and "the unexpected" to supplement the audio-tape recordings during each session. This was at best a subjective evaluation of the "worthwhile event." It has been interesting to note that there was a considerable increase in the quality and quantity of the author's observational notes from the first few sessions to the final sessions. Therefore, there were limitations to these observations. Noteworthy events may have occurred which were not recognized as important at the time. On the other side of the coin, notes were often taken on occurrences that in retrospect appear to have little if any importance. Keeping these limitations in mind, the author will attempt to rely on non-statistical, subjective evaluation of the first research hypothesis.

> Hypothesis A: There are unique motivational and interactive trends and patterns that occur when adolescents interact with a microcomputer.

### The Microcomputer

The Commodore PET microcomputer machine was very reliable and no breakdowns were experienced. Twice in the 85 sessions, there was an unexplained interference in a running program which was probably due to electrical surges of power for which school buildings are known. This meant loss of data stored in the computer memory and the program had to be started over again. This delay time was considered in computing subject work time and was not counted against them. It was necessary to build into the programs many safeguards to counteract impulsive subject behavior such as idly tapping on keys while waiting for a teammate to finish writing and causing an error message, or pressing the return key two or three times in impatience and prematurely ending the display of a clue or the entire program.

It was obvious from the first session that seventh and eighth graders would adapt very quickly to the mechanics of working with a microcomputer. After the initial message on the screen about the research project, each subject was requested to type in his/her own ID number and data concerning him/herself. In this way, each subject immediately manipulated the machine. There was no hesitancy. In all cases, subjects remembered necessary commands to run the programs (eg. RUN, RETURN) from session to session even when a week of time intervened.

About 250 permission slips were handed out from which 87 students responded with signed permission. Once the sessions were begun, subject interest was consistently high. Once begun no one withdrew or indicated in any way that they wished to. This was true even with individuals who worked alone or in groups where no problem was solved during the three sessions. Most subjects returned to the second and third session promptly and eagerly; in some cases literally on the run.

In one case, just before a first session was to begin, the author was in the office checking the attendance list when the mother of one of the afternoon session subjects came in to take her son out of school for a doctor's appointment. The author mentioned that that would mean he would miss his scheduled computer sessions. The mother insisted that he go ahead with the research session; that the work with the computer was important--she would get another appointment with the doctor.

## Group Seating

As indicated previously, the author placed chairs in a set pattern in the front of the microcomputer, centering the chairs as much as possible for the various sized groups. Subjects were free to arrange chairs as they wished. Most did not change the arrangement. One pair of subjects placed one chair directly in front of the screen and the other chair off to the side. The one who sat directly in front assumed a leadership role in the problem session.

In the groups of five, the chairs were arranged three in front and two centered in a second row. Most groups kept that arrangement. Many within the group changed seating positions during the second and third sessions by common consent or who got there first. One group moved four chairs into a front row which left one person seated behind all the others. It was observed that the back row subject(s) tended to take less part, had their requests and suggestions ignored more, and often showed less interest as the session progressed.

## Solving a Complex Problem

All subjects were told at the beginning session that the author would help them only with the mechanics of the microcomputer; they would receive no help with the problem itself.

In all cases, subjects indicated that they were unfamiliar with this particular style of problem requiring a complex solution. They did not know how to go about solving it and learned by trial and error. Several subjects tried to "answer" each individual clue even though they were not stated in question form. Some looked at all twenty clues, writing nothing. When they were asked for specific parts of the solution, it was necessary to go back, look at all the clues again and take notes. It appeared that once a method was developed, problems two and three were tackled with confidence and with what they considered a workable strategy.

Some subjects persisted in one strategy throughout (e.g. writing the entire text of each clue and analyzing clues at the end); others were willing to change strategy if it seemed workable (e.g. matrix strategy of organizing data).

## Group Interaction

Most subjects were insistent that everyone in the group would have a turn to type, choose a clue, and to be seated in an optimal seating position. Some resorted to voting (this method only lasted one round--it took too long), coin flipping, or using ID number sequence for the order of turns.

In many groups, the subjects worked as a team with no leader apparent. In some groups one individual directed the strategy. This was most pronounced in groups of five where it occurred in five out of six groups. Definite leadership appeared in groups of two or three if there was an ability discrepancy of two or more levels within the group (as measured by grade average). Then the higher ability subject took over.

In all groups but one, all subjects in the group took part, some to a lesser degree than others. In that one group (5D), one subject directed the task strategy, collected information and attempted to reach a solution with almost no help from the other four subjects in the group. He had to give up in the first two sessions. In the third problem session, as the parts of the solution began to be labeled correct one by one, the entire group became vocal, interested, helpful and the group together finished the solution of the problem.

### Ability Levels and Interaction

Subjects who were within one grade average level of each other appeared to work well together, understanding the reasoning of the other(s), and respecting each other's opinion.

Subjects in a group who were two or more grade average levels apart were discordant in their voice and actions with a great deal of friction that increased throughout the three sessions. In some cases the lower ability subject was ignored. There was a definite lack of understanding of each other's strategy.

The "D" grade average subjects in a group tended to do the mechanical tasks (type on the microcomputer), preferred not to write, were easily distracted, easily bored, and became frustrated with the logical and methodical strategy of others. Working individually or within a group, they tended to be erratic, impulsive, quick to accept another opinion, sought authority approval (from the author), and needed encouragement. These subjects tended to do more guessing, using ideas not supported by given facts.

Only one of the research subjects who worked by herself had a D grade average. In fact she had as many Es on her card as Ds and was 14 years old in the eighth grade. She had heard about the microcomputer sessions at school but was not in either afternoon study hall classes. She brought a written permission letter from her father and requested that she participate after school. The school counselor expressed skepticism that this student would even show up, much less do much for the research and made a point of reminding her early in each scheduled day not to take the bus home but to stay in school.

Subject #65 came in hesitantly, had never seen a microcomputer before, and hoped "that it wasn't about social studies; I'm not good at social studies." During the first session she asked many questions about the procedure, had a great deal of difficulty comprehending just what the task was, and needed reassurance that she was proceeding OK. She spent several minutes on each clue, taking several seconds between pressing each key. She avoided using the categories but called for all clues by number. She gave up after 40:01 minutes having only four parts of the twelve part solution correct.

For the second session she not only returned but related that she had boarded the bus, remembered the research session and rushed off the bus, coming in breathless. She worked with the problem with much more confidence, remembering the mechanics of RUN and RETURN commands on her own. Much less time was taken in typing in the clue number. In fact, as the sessions progressed it seemed that her confidence was directly proportional to her typing speed. She gave up after 42:14 minutes having seven parts of the nine part solution correct.

In the third session, #65 was very vocal, confident, interested in the problem and analyzed the task well. She took 45:35 minutes with the problem and solved eight parts of the nine part solution correctly. Even though she had to give up, she indicated that she felt good about her experience.

This case is particularly important because much of the reported use of microcomputers has been with accelerated students and classes, and the gifted programs. Most school administrators and teachers that the author contacted and worked with in this study expressed surprise that the recruiting would include _everyone_. The implication given that low academic achievers would not do well. This is one instance of a very low academic achiever who improved in every session, developed confidence and exhibited enthusiasn about working on a complex problem with a microcomputer. Would she have done as well if it had been on paper with a pencil?

## Two Problem-Solving Examples

Problem-solving has been defined as "a series of mental processes which involve distinguishing the relevant attribute of the problem, testing these attributes, and proposing a solution.

These internal processes are hypothesized from the output behaviors of subjects solving experimental tasks" (Biglan, 1977). In this study it was impossible to follow the thinking and strategy of the individual working alone; there was little if any "output behavior." Groups who wrote most of the clue text did little talking until the very end of the session. It was the vocal teams who gave insight to their thinking and strategy to the author that suggest that this kind of challenging problem-solving can be valuable in the development of logical reasoning skills needed by the literate citizen.

Although it is difficult, if at all possible, to reproduce the excitement and enthusiasm by the written word, transcripts of the taped conversation of a group of two and a group of five will highlight the scope of the reflective, corrective thinking and frustrations of seven seventh graders.

In the tape transcript which follows, group 2F was solving the problem, "Energy at Home." Two seventh grade males with grade averages of A and B took 21:48 minutes to solve the problem.

A second tape transcript has been placed in Appendix G in the interests of textual continuity. The reader is encouraged to read the record of group 5A solving the problem, "Global Travelers." Four seventh grade males and one seventh grade female with four B grade averages and one C took 19:16 minutes to solve the problem.

## Transcript of Taped Session Conversation

Group: 2F
Program: Energy at Home
Subjects: 2 seventh grade males (S1, S2)
Solution time: 21:48 minutes

S1: "3 teachers meet on the last Wednesday of the month to play cards. Your task is to match the name of the teacher with the kind of fuel they burn and the temperature setting in each home."

S2: This is going to be wierd!

S1: Don't say, I like it warm. "There are 20 .... When you think you know ...."

S2: OK, go on.

S1: "Remember your task is to ...."

S2: Just put N2.

S1: N2? "Teacher? Temperature setting? Kind of fuel? About conserving fuel?" OK, N2. Return. Write this down!

S2: OK.

S1: "One of the teachers knows ...." Just put down "One teacher."

S2: (Writing) One teacher.

S1: "... knows that his fuel resource will probably run out ...." Oil or gas or something. Its not clear. Let's do it a different way.

S2: Wait. I didn't have time to .... "... decade or two." OK, N4.

S1: Why do you want N4? I don't like that. (Types N4) "Everyone wears a sweater when they visit Mr. Jones at his house." Put down, "Mr. Jones, cold house." Ready?

S2: Yeah, N6. You do it this time.

S1: (Reading) "There is a difference of 5 degrees in two of the houses." 5 degrees difference.

S2: In two houses? Or in two of the houses? OK, go on. N8.

S1: "The difference in Mr. Jones and Mr. Lawrence's .. ." Put down Mr. Lawrence, his name, home temperature is twice as much as ...

S2: Hey, we got to know how to spell it! No, *Mrs*. Lawrence's?

S1: Excuse *me*! *That* would have been a big mistake. No, its *Mr*. Lawrence!

S2: *Ms*. Lawrence, yeah? Law-rence. OK, and Ms. Brown .... Wait! This is crazy.

S1: "The difference in Mr. Jones' house and Mrs. Lawrence's ...."

S2: So then it can't be 5 between Mr. Jones and Mrs. Lawrence--*Ms*. Lawrence because then their's would have to be 2.5 degrees.

S1: (Rereading task) "Your task is to match each teacher with the kind of fuel they burn and the temperature setting." "The difference in Mr. Jones and Mr. Lawrence's home temperature is twice as much ...." So Mr. Jones and Mr.--*Mrs*. Lawrence home temperature is twice as much ....

S2: difference ...

S1: of ...

S2: as ...

S1: Ms. Brown and Ms. Lawrence.

S2: OK. I put; Mr. Jones, Ms. Lawrence, twice the difference as, you know, Ms. Brown, I don't remember. You know ....

S1: Return.

S2: N10.

S1: "The apartment building is 5 degrees warmer than Mr. ..."

S2: *Ms*. Brown. OK N12!

S1: "Ms. Brown insultated her house last fall and cut her heating bill ...."

S2: (Writing) Ms. Brown, insultated, heating bill, half ....

S1: (Typed N14) "The teacher who liked sweaters is worried about his fuel supply and is planning to install solar panels." Oh, this is the one with the sweaters! OK. You ready?

S2: (Writing) Wait a minute! OK, go on. 16!

S1: Return. 16.

S2: No. N16.

S1: (Types N16) "Mr. Brown set his thermostat at 5 degrees higher than Mr. Jones." OK, put that under Brown. 5 degrees higher than Jones. Ready?

S2: (Writing) Ms. Brown, 5 degrees higher than Mr. Jones.

S1: Return. 18.

S2: You got to press "N" first!

S1: 18. Return. "Ms. Brown feels too warm at Ms. Lawrence's house." So put it down under Ms. Brown, feels too warm at Ms. Lawrence.

S2: Ms. Lawrence house; too warm for Brown. How many did each have?

S1: Return. (Typed N20) "The presidential recommendation for desirable daytime temperature is 68°."

S2: Who cares?

S1: So! 68°. These are all somewhere around 68°.

S2: I know that, but, who cares? Oh, go on. What do we need to know ...?

S1: Put "Pres., 68, recommended."

S2: (Writing) Pres., rec., 68. N1, N1, N1!

S1: N1. Return. "Ms. Brown follows the presidential recommendation for ..."

S2: Hey, that's cool! 1 and 20 match up!

S1: Just put it down! But then Ms. Brown's house is 68°! Put it down under here. 68°.

S2: (Writing) Ms. Brown, 68°.

S1: Return. N3. Return. "There is a central heating system in Ms. Lawrence's apartment building and she cannot control the level of heat." She lives in the apartment! Who is the one that's in the apartment?

S2: OK. Ms. Lawrence in apartment. And the apartment building was 5° warmer than Brown house so we know--ah--Lawrence--73°. What do we have to find out? "Match each teacher's name with the kind of fuel they burn ...."

S1: Return. Hold it! If Mr. Jones was 5° difference than the temperature of the two houses ....

S2: Apartment building, 5° warmer than Brown's house. And I know Brown was 68°. So the apartment building was 73°.

S1: N5. Return. "The apartment building manager will soon be getting fuel from the western states."

S2: Coal! Soon be getting fuel. What does that do? Look under Ms. Lawrence. Go on.

S1: Return. N7.

S2: "The very ..." Oh, great! We know that! We know that shale is coal! Quick! Hit it real fast!

S1: (Hitting the wrong key) Oh, oh!

S2: Instant delete!

S1: Return. (Types N9) "Mr. Brown worries about ...." (OPEC decision)

S2: Oh, yeah! Yeah! Yeah! Um--OIL!

S1: Oil.

S2: I was thinking of--um--what was I thinking?

S1: (Return, N11) Look!

S2: It has a ... Hey!

S1: Mr. Jones' heating bill is less than his teacher friends."

S2: Than his two teaching friends.

S1: Hold it! Ms. Jones!

S2: No! Mr. Jones! You get them all mixed up!

S1: It's a cold house and there's 5° difference in the temperature between the two other houses.

S2: Low cost. Return.

S1: You think Mr. Jones is something like 63°?

S2: No. It can't just ... Wait! Mr. Jones, twice the difference ... Mr. Jones and Ms. Lawrence is twice the difference between ... Wait! Don't do anything! Mr. Jones and Ms. Lawrence. The difference from theirs is twice the difference of Ms. Lawrence and Ms. Brown. 10 degrees different? He keeps his either 63° or 83°. I think all we need ....

S1: I think it's 63° cause he's the low count heating bill ....

S2: OK. Let me fix it.

S1: All right! If you get your jollies! I'll press the number. (N13) "Mr. Jones chose the cleanest fuel available." What's the cleanest fuel?

S2: I don't know what's the cleanest .... It was on that thing. (Inventory)

S1: Gas!

S2: Natural gas!

S1: No. OK.

S2: Let me write down; clean fuel.

S1: Lets go! (Types N15) "Ms. Lawrence often wears shorts and goes barefoot in her apartment on the coldest winter day."

S2: Oh--Wow! That tells us a lot!

S1: So, she has a cold apartment!

S2: No. It's warm (laughter). She goes barefoot because her apartment is cold? 17.

S1: "Natural gas is considered the cleanest fuel."

S2: Yeah. We know he burns ....

S1: Natural .... We'd better go to 19.

S2: All we need is Ms. Lawrence.

S1: We don't have Mr. Jones at all!

S2: Yes! We know that Mr. Jones keeps his house at 63° and he burns natural gas. We probably have Ms. Lawrence somewhere.

S1: Isn't there another lady somewhere?

S2: I know there's a ....

S1: There's only 3 ladies? There's more than 3 ladies! Mr. Jones ...

S2: There's *2* ladies! 19!

S1: "Many believe ..." Oh!

S2: She's natural gas I think cause ....

S1: She wouldn't use natural gas!

S2: Ms. Brown installed heat ... I mean ... Ms. Brown insulated; heat bill half.

S1: She used oil cause she was worried about the OPEC nations. There's only *3* people?

S2: OK. Mr. Jones, cold house. OK! 5° difference, room temperature, two of the houses. Yeah! One teacher knows that his fuel resource will probably run out in the next decade or two. Ms. Lawrence ... Where was it? Wasn't Ms. Lawrence the apartment building too warm for Brown. OK! Apartment building 5° warmer than Brown house. But it said something about the apartment building was going to switch ....

S1: I don't think that that's natural gas.

S2: The apartment building is soon going to switch to coal shale. But it doesn't say that they use that now!

S1: So they switch to coal?

S2: Yeah!

S1: Want to try it? (The solution)

S2: But it says they *soon* switch to coal! So that means that now it's using something that is using a lot of energy. I mean ....

S1: "Your task it to match each teacher's name with the kind of fuel they *burn*."

S2: How can they burn coal?

S1: Use!

S2: Just press return!

S1: But ...

S2: I don't want to give up. "Got the solution ...."

S1: We got half of it! All we gotta know is what Mr. Jones uses ....

S2: No! What Ms. Lawrence burns. That's what we gotta know. Think! It doesn't say anything about it .... It doesn't say anything....

S1: One teacher knows that his fuel resource will probably run out. That's the one with the oil, Ms. Brown. Mr. Jones' house, 5° ... Mr. Jones, twice the difference ... Ms. Lawrence ... Ms. Lawrence, house warm for ... Apartment building ... Ms. Brown insulated her ... insulated, heat bill half ....

S2: Just put coal for Ms. Lawrence. Cause I don't think they would have one of each of these things, wouldn't they?

S1: Well, which one used the clean one?

S2: Mr. Jones!

S1: No! Mr. Jones had oil!

S2: I'm positive Mr. Jones used the clean one. And I'm positive he used natural gas and I'm positive that Ms. Brown used oil. And I know that in a few months Ms. Lawrence will use natural gas ... I mean coal ....

S1: Coal!

S2: But right now I don't know what the apartment building uses. Well, we have to solve it now anyway--so!

S1: (Types in N2 for solution) "Teacher?" Mr. Jones! We know what Mr. Jones uses. (Types in "Mr. Jones").

S1: "What kind of fuel does Mr. Jones burn?" (Types in "oil"; gets a "not correct" response). What? Oh! He burns natural gas! (Types in "natural gas") "What is the temperature setting?" 63°. "What is the name of another teacher?" (Types in Ms. Brown, oil, 68° and gets a "correct" response.)

S1: (Types in "Ms. Lawrence") Now that's the thing we don't know. Now think! Coal. Let's try coal and see what it says.

S2: Yeah! We goofed up on the other ones and they don't count as bad. So how can we do worse.

(Correct responses were typed in. Problem solved!)

S2: We did bad!

(Both take the time to analyze their clue choices at the end.)

## Summary

Sixty-six seventh and eighth grade subjects completed a series of three interactive problem-solving tasks on a PET microcomputer.

After responding to a Cognitive Inventory survey an identification number was assigned and subjects were randomly assigned, within time restrictions, to individual sessions or to teams of two, three, or five.

Within a normal class period, half the subjects worked on consecutive days, the other half met once a week. Half the subjects received a special training session on organizing data ("Try a Matrix"), half received no special session.

All programs and instruments were original creations written and/or adapted for a microcomputer. An analysis of readability indicated that program text difficulty ranged from grade levels 3.1 to 4.8 within the four programs.

Data were collected on ten independent variables (sex, age, grade, grade average, computer experience, group size, received matrix training, verbal reasoning test score, cognitive inventory test score, and frequency of research session), and six dependent variables (use of paper, use of matrix, number of problems solved, time to solution for each problem, number of clues asked for in each problem, and order of clues asked for).

Groups had to finish all three scheduled sessions to be included in the research data. "Broken" groups were replaced by a newly formed group.

Subjects were recruited from four buildings in neighboring school districts in suburban metropolitan Detroit. Research sessions were held in a variety of types of rooms ranging from absolute privacy to the "goldfish bowl" atmosphere of a glassed in media center conference room. Seating was standardized for similar sized groups and paper and pencil were always available for use.

Thirty-nine seventh and twenty-seven eighth grade students were recruited from study hall classes, the gifted program in one of the schools, and, in the absence of afternoon study halls, science classes. There were no restricting criteria for participation. A full range of abilities were represented as indicated by verbal reasoning/total language test scores (1-99) and current grade averages (D to A). Microcomputer interaction was new to most of the subjects as 64% indicated that they had never used a computer of any kind before. A correlation matrix indicated a range of significant correlations from -.2605 to .6577 between pairs of seven independent variables. Higher correlations were indicated between age and grade, grade average and verbal reasoning tests, grade average and Cognitive Inventory, and verbal reasoning tests and the Cognitive Inventory. Low correlations were indicated between computer experience and verbal reasoning test scores.

Anecdotal observations are at best a subjective evaluation by the researcher, but unknown and unexpected patterns and trends can be identified for further study supporting the premise of Research Hypothesis A.

Subjects appeared to adapt very quickly and easily to the mechanics of the microcomputer. Subject interest remained consistently high throughout all sessions. There were no withdrawals. There were also indications of considerable parent interest.

Group seating was regarded as an important factor in group interaction because of the small microcomputer display screen. Most students did not change the standardized seating arrangement although they were free to do so. Those subjects who did change the seating also exhibited tension, discordance, and lack of team effort within the group.

All subjects indicated that they were unfamiliar with this particular style of complex problem. First sessions involved "trial and error" methods. Second and third problems were attacked with increased confidence and improved strategies. Some subjects persisted in the original strategy, others were more open to change.

Most individuals within groups insisted on everyone taking turns. In those groups where turns were not taken in a somewhat organized fashion, friction within the group usually resulted. In most groups everyone took part in the deliberations to some degree.

Subjects who were within one letter grade average worked together as a team. Subjects who were two or more grade average levels apart had difficulty working together and did not seem to understand the strategy employed by the other(s). The "D" grade average subjects were erratic, impatient, impulsive and demanded attention, approval and encouragement from the adult present.

Transcripts of two research sessions highlight the involvement, teamwork and scope of the problem-solving process. In a much shorter version, some "quotable quotes" may provide a briefer "feel" of session reactions and interactions.

"China isn't outside Paris!"
"Paris isn't a capital city, its a country."
"Is Italy in France?"
"Is Braniff his last name?"
"Where is the Midwest? In Tennessee?"
"Is Egypt in the Western Hemisphere?"
(About the irrelevant clue) "But what happened to Pat?"
"Central heating: would that be a radiator?"
(About a vertebrate) "That's a worm! Who would have a worm for a pet?"
(About grammar) "'Were' means they died!"
"Let's try something different."
"Don't press buttons so fast."
"Oh, we had it! But we didn't put anything down!"
"I don't want to give up. I'll go as far as I can."
"Let's check that out. Lets ask more questions."
"I love mysteries!" (Fastest solution time, 10 minutes)
(To another student) "We don't need you. Go get your own computer."

# CHAPTER IV

# PRESENTATION OF DATA AND STATISTICAL ANALYSIS

## Introduction

This chapter presents the data and statistical analysis of the study. The research design is described and null hypotheses are presented and tested. Tests of significance are provided for both individual subjects and groups wherever feasible to give as complete a picture of influences as possible. Major focus is on programs that are solved. There was no analysis of unsolved programs. A search was conducted for previously unrecognized interactions in a section entitled "Questions of True Interest." Results of a final test of significant variable influences is presented which included all independent and dependent variables and the study treatment.

Data were collected from sixty-six seventh and eighth grade subjects assigned to twenty-four groups for a total of seventy-two research sessions. As was reported in Chapter III, this group of subjects included a full range of possible abilities and achievement. Within each group size there also was a wide range of ability and achievement. However, the sample cannot be assumed to be random since volunteers were solicited and subjects were assigned to groups and sessions as time and schedule permitted. Data were considered for ten independent and nine dependent variables.

## The Research Design

This research study could be classified as a quasi correlational design. According to Bruce Tuckman (1972), a correlational study involves the collection of two or more sets of data from a group of subjects to determine the subsequent relationships between the sets of data. The specific research design of this study is represented symbolically in Figure 15.

Both the Michigan Interactive Data Analysis System (MIDAS) on The University of Michigan Terminal System (MTS) and data analysis programs on the Commodore PET microcomputer were used to compute the tests of significance for this study. Twenty of the fifty tests presented in this study were completed on a microcomputer.

## The Null Hypotheses

Null hypotheses were developed for each of seven of the research hypotheses and are summarized below:

> Null Hypothesis B: As each successive program is played, there is no significant difference in the time required to reach a correct solution. (Research Hypothesis: Students will improve their skill by decreasing the time required for correct solution.)
>
> Sub $H_0$ B1: There is no significant difference in the time required to reach a correct solution from program one to program two.
>
> Sub $H_0$ B2: There is no significant difference in the time required to reach a correct solution from program two to program three.
>
> Sub $H_0$ B3: There is no significant difference in the time required to reach a correct solution from program one to program three.

| | | | | | | |
|---|---|---|---|---|---|---|
| $C_1$ | $C_2$ | $C_{41}$ | X | $0_1$ | $0_2$ | $0_3$ |
| $C_1$ | $C_2$ | $C_{41}$ | □ | $0_1$ | $0_2$ | $0_3$ |
| $C_1$ | $C_2$ | $C_{42}$ | X | $0_1$ | $0_2$ | $0_3$ |
| $C_1$ | $C_2$ | $C_{42}$ | □ | $0_1$ | $0_2$ | $0_3$ |
| $C_1$ | $C_2$ | $C_{43}$ | X | $0_1$ | $0_2$ | $0_3$ |
| $C_1$ | $C_2$ | $C_{43}$ | □ | $0_1$ | $0_2$ | $0_3$ |
| $C_1$ | $C_2$ | $C_{45}$ | X | $0_1$ | $0_2$ | $0_3$ |
| $C_1$ | $C_2$ | $C_{45}$ | □ | $0_1$ | $0_2$ | $0_3$ |

Where C = covariates:

$C_1$ = cognitive survey scores

$C_2$ = program cell size

$C_3$ = random order of programs

$C_4$ = size of group

$C_5$ = time lapse in participation

Where 0 = observations:

$0_1$ = number of games solved

$0_2$ = total time to solution

$0_3$ = number of times matrix strategy was used

Where X = treatment (matrix training)

Figure 15. The Research Design of the Study

Null Hypothesis C: There is no significant difference in the use of a matrix strategy between the subjects who participate in an interactive matrix training session and those who do not. (Research Hypothesis: Subjects with training will use the matrix strategy more.)

Null Hypothesis D: There is no significant difference in the time needed for a correct solution between the groups in which at least one student used the matrix strategy and those groups in which no student used the matrix strategy when computed by position in the three program sequence. (Research Hypothesis: Groups using the matrix strategy will require less time.)

Null Hypothesis E: There is no significant difference between the number of subjects on a team and the time required to reach a correct solution. (Research Hypothesis: There is a curvilinear relationship between group size and time to solution.)

Null Hypothesis F: There is no significant difference in the number of subjects in a group and the achievement of a correct solution as measured by the number of programs solved. (Research Hypothesis: There is a curvilinear relationship between group size and achieving a correct solution.)

Null Hypothesis G: There is no significant difference in the difficulty of the three microcomputer programs when presented in random order. (Research Hypothesis: The three programs are of approximately equal difficulty.)

Sub $H_0$ G1: There is no significant difference when measured by number of programs solved.

Sub $H_0$ G2: There is no significant difference when measured by time to solution.

Sub $H_0$ G3: There is no significant difference when measured by number of clues required for solution.

Null Hypothesis H: There is no significant difference between the achievement of groups who attempt to solve problems on three consecutive days and those groups who attempt to solve problems on a once-a-week basis. (Research Hypothesis: Daily problem-solvers will show greater achievement.)

Sub $H_0$ H1: There is no significant difference when measured by number of programs solved.

Sub $H_0$ H2: There is no significant difference when measured by the time needed for solution.

Null Hypothesis B

Null Hypothesis B was tested using the Pairwise T-Test, Matched Analysis of Variance, and Matched Pair T-Tests to compare the mean time needed to solve programs between the three successive programs. The data were analyzed in two ways: by individual subject time to solution, and by time to solution per group. Since each individual in a group had the same solution time and reflected group effort rather than individual effort, it was felt that both analyses would be a more rigorous check of the significance of the hypothesis. Only data from individuals and groups who solved all three problems were included.

> Null Hypothesis B: As each successive program is played, there is no significant difference in the time required to reach a correct solution. (Research Hypothesis: Students will improve their skill by decreasing the time required for correct solution.)
>
> Sub $H_0$ B1: There is no significant difference from program one to program two.
>
> Sub $H_0$ B2: There is no significant difference from program two to program three.
>
> Sub $H_0$ B3: There is no significant difference from program one to program three.

The results of these analyses are presented in Tables 6, 7, and 8. An examination of the Pairwise T-Tests for forty-three subjects in Table 6 indicated that all times decreased significantly in subsequent programs rejecting Null Hypothesis B. It should be noted that the mean time differences were greater comparing program one and two, and program one and three. This could be explained by the exploratory nature of program one and the honing of developing skills in program three. Much less difference was indicated between programs two and three.

## TABLE 6

## PAIRWISE MULTIPLE COMPARISONS IN THE TIME NEEDED FOR SOLUTION BETWEEN THE THREE PROBLEM-SOLVING PROGRAMS

| Variable | Mean | Mean Diff. | Std. Dev. | T-Stat. | Signif. |
|---|---|---|---|---|---|
| Time 1 | 25.967 | 3.7628 | 6.3280 | 3.8992 | .0003 |
| Time 2 | 22.205 | N=43 | | | |
| Time 1 | 25.967 | 5.9326 | 7.7516 | 5.0186 | .0000 |
| Time 3 | 20.035 | N=43 | | | |
| Time 2 | 22.205 | 2.1698 | 5.1754 | 2.7492 | .0088 |
| Time 3 | 20.035 | N=43 | | | |

## TABLE 7

## MATCHED T-TESTS COMPARING GROUP TIME NEEDED FOR SOLUTION BETWEEN THREE PROBLEM-SOLVING PROGRAMS

| | Compared Programs | | | | | |
|---|---|---|---|---|---|---|
| Measures | First | Second | Second | Third | First | Third |
| N | 14 | 14 | 14 | 14 | 14 | 14 |
| $\bar{X}$ | 27.207 | 23.179 | 23.179 | 21.343 | 27.207 | 21.343 |
| S.D. | 8.522 | 5.329 | 5.329 | 4.871 | 8.522 | 4.871 |
| t | 2.281 | | 1.1573 | | 2.597 | |
| df | 13 | | 13 | | 13 | |
| sig. @ .05 | 2.160 | | 2.160 | | 2.160 | |

## TABLE 8

### MATCHED ANALYSIS OF VARIANCE COMPARING GROUP TIME NEEDED FOR SOLUTION BETWEEN THREE PROBLEM-SOLVING PROGRAMS

| Group | Mean | Standard Deviation |
|---|---|---|
| First | 27.2070 | 8.5220 |
| Second | 23.1785 | 5.3289 |
| Third | 21.3428 | 4.8710 |

| Source | Sum of Squares | D.F. | Mean Squares |
|---|---|---|---|
| Rows | 970.489502 | 13 | 74.6530386 |
| Groups | 251.949036 | 2 | 125.9745180 |
| Int. Act. | 651.317597 | 26 | 25.0506768 |
| Total | 1873.756130 | 41 | |

F value of rows = 2.98008071 sig. @ .05 = 2.125
F value of groups = 5.028787 sig. @ .05 = 3.370

An examination of the Matched T-Tests for 14 groups in Table 7 indicated that the same relationship exists as in Table 6. In this test differences in the time in the first and second programs, and in the first and third programs were significant at the .05 level but the differences in the second and third programs were not significant. Part of this variance from results in Table 6 could be explained by a smaller number of degrees of freedom.

An examination of the Matched Analysis of Variance for 14 groups in Table 8 indicated again the same relationship of significantly decreasing mean times. Using a total df of 41, all F values were significant at the .05 level.

Therefore Null Hypothesis B of no significant differences in times to solution was rejected and the research hypothesis was supported.

## Null Hypothesis C

Chi Square Tests were used to analyze Null Hypothesis C by (1) using totals from all subject working papers in all programs and (2) by using totals from the second and third programs only. Matrix training was given after the first program so influence would only be felt in the second and third programs. When all papers were used, all first program papers were regarded as no-training papers resulting in a much larger N for that category. As a point of interest the analysis was extended to examine the matrix use for (1) subjects working with programs every day, and (2) subjects working with programs once-a-week.

> Null Hypothesis C: There is no significant difference in the use of a matrix strategy between the subjects who participate in an interactive matrix training session and those who do not. (Research Hypothesis: Subjects with training will use the matrix strategy more.)

The results of these analyses are presented in Tables 9-12.

An examination of Tables 9 and 10 indicate that there were significant differences in all of the observed frequencies in both all papers/all programs and the more restricted Ns of the second and third programs only. Therefore the null hypothesis of no significance was rejected and the research hypothesis was supported.

An examination of matrix use in every day sessions and in once-a-week sessions in Tables 11 and 12 indicated no significant differences in the every day sessions but highly significant

## TABLE 9

## CHI SQUARE TEST FOR DIFFERENCES IN THE USE OF A MATRIX STRATEGY WITH AND WITHOUT TRAINING IN ALL PROGRAMS

| | After Training | No Training |
|---|---|---|
| Used Matrix | 42 | 45 |
| No Use of Matrix | 11 | 62 |

| Column | Observed Value | Expected Value | Chi Square Contribution |
|---|---|---|---|
| 1 | 42 | 28.82 | 6.03 |
| | 11 | 24.18 | 7.19 |
| 2 | 45 | 58.18 | 2.99 |
| | 62 | 48.82 | 3.56 |

Chi Square = 19.76 df = 1 Sig. @ .0000008

## TABLE 10

## CHI SQUARE TEST FOR DIFFERENCES IN THE USE OF A MATRIX STRATEGY WITH AND WITHOUT TRAINING IN 2ND AND 3RD PROGRAMS

| | After Training | No Training |
|---|---|---|
| Used Matrix | 42 | 28 |
| No Use of Matrix | 11 | 28 |

| Column | Observed Value | Expected Value | Chi Square Contribution |
|---|---|---|---|
| 1 | 42 | 34.04 | 1.86 |
| | 11 | 18.96 | 3.34 |
| 2 | 28 | 35.96 | 1.76 |
| | 28 | 20.04 | 3.16 |

Chi Square = 10.14 df = 1 Sig. @ .001

## TABLE 11

## CHI SQUARE TEST FOR DIFFERENCES IN THE USE OF A MATRIX STRATEGY WITH AND WITHOUT TRAINING IN DAILY SESSIONS

| | After Training | No Training |
|---|---|---|
| Used Matrix | 15 | 30 |
| No Use of Matrix | 9 | 33 |

| Column | Observed Value | Expected Value | Chi Square Contribution |
|---|---|---|---|
| 1 | 15 | 12.41 | 0.54 |
| | 9 | 11.59 | 0.58 |
| 2 | 30 | 32.59 | 0.21 |
| | 33 | 30.41 | 0.22 |

Chi Square = 1.54 df = 1 Sig. @ 0.214

## TABLE 12

## CHI SQUARE TEST FOR DIFFERENCES IN THE USE OF A MATRIX STRATEGY WITH AND WITHOUT TRAINING IN ONCE-A-WEEK SESSIONS

| | After Training | No Training |
|---|---|---|
| Used Matrix | 27 | 15 |
| No Use of Matrix | 2 | 29 |

| Column | Observed Value | Expected Value | Chi Square Contribution |
|---|---|---|---|
| 1 | 27 | 16.68 | 6.38 |
| | 2 | 12.32 | 8.64 |
| 2 | 15 | 25.32 | 4.20 |
| | 29 | 18.68 | 5.69 |

Chi Square = 24.91 df = 1 Sig. @ .0000005 differences in the once-a-week sessions. This may be explained by the possibility that the reinforcement of the program solution being given in matrix form in each program may have had more influence from one day to the next and less influence with a week between each session for those subjects who have not had training. These results showed overall support for the results in Tables 9 and 10, therefore there is no cause to question the rejection of Null Hypothesis C.

## Null Hypothesis D

Null Hypothesis D was tested using the Point Biserial Correlation analysis. This treatment was used because the variable of time was measured in a graduated fashion and the data concerning the use of a matrix was a discrete dichotomy.

> Null Hypothesis D: There is no significant difference in the time needed for a correct solution between the groups in which at least one student used the matrix strategy and those groups in which no student used the matrix strategy when computed by position in the three program sequence. (Research Hypothesis: Groups using the matrix strategy will require less time.)

The results of this analysis are presented in Table 13.

An examination of Table 13 indicated that there was no significance at the .05 level, therefore, supporting the null hypothesis and rejecting the research hypothesis.

A further analysis of the same data by position of the program in the three program sequence was conducted to determine the difference, if any, in the significance within the first, second, or third program session. The results of this Point Biserial Correlation Analysis are presented in Table 14.

TABLE 13

THE POINT BISERIAL DISTRIBUTION OF MATRIX USE WITH TIME FOR ALL SOLVED PROGRAMS BY GROUP

| Time in Minutes | Matrix Used | Matrix Not Used | Totals |
|---|---|---|---|
| 39-40.9 | 1 | 1 | 2 |
| 37-38.9 | 1 | | 1 |
| 35-36.9 | 1 | 1 | 2 |
| 33-34.9 | | | 0 |
| 31-32.9 | 3 | 3 | 6 |
| 29-30.9 | 2 | | 2 |
| 27-28.9 | 3 | 1 | 4 |
| 25-26.9 | 5 | 4 | 9 |
| 23-24.9 | 2 | 2 | 4 |
| 21-22.9 | 3 | 2 | 5 |
| 19-20.9 | 6 | | 6 |
| 17-18.9 | 6 | 1 | 7 |
| 15-16.9 | 4 | | 4 |
| 13-14.9 | 2 | 1 | 3 |
| 11-12.9 | | | 0 |
| 9-10.9 | 1 | | 1 |
| Totals | 40 | 16 | 56 |
| Percent | 71 | 29 | 100 |
| Means | 23.02 | 26.35 | 23.97 |

$r_{pb} = -.2205$

.05 sig. @ .25

## TABLE 14

## SUMMARY OF POINT BISERIAL CORRELATIONS OF MATRIX USE WITH TIME-BY-PROGRAM SESSION FOR ALL SOLVED PROGRAMS BY GROUP

| | First Program | | | Second Program | | | Third Program | | |
|---|---|---|---|---|---|---|---|---|---|
| | Matrix | No Matrix | Totals | Matrix | No Matrix | Totals | Matrix | No Matrix | Totals |
| N | 10 | 8 | 18 | 14 | 5 | 19 | 16 | 3 | 19 |
| Percent | 56 | 44 | 100 | 74 | 26 | 100 | 84 | 16 | 100 |
| $\bar{X}$ | 27.7 | 28.3 | 27.99 | 21.7 | 24.3 | 22.39 | 21.2 | 24.7 | 21.8 |
| S | | | 7.48 | | | 4.70 | | | 6.0 |
| $r_{pb}$ | | -.0420 | | | -.3815 | | | -.4894 | |
| .05 Sig. | | .444 | | | .433 | | | .433 | |

An examination of Table 14 indicated that while there were no significant differences in programs one and two, there was a significant difference in time needed in program three. This may be explained by the development of strategy and problem-solving skills by the third session so that the use of the matrix strategy could facilitate solution time. These results would indicate that while there was one part that was significant, on the whole the null hypothesis should not be rejected but further study would be warranted.

## Null Hypothesis E

Null Hypothesis E was tested by individual subject time to solution by using a Univariate 1-way Analysis of Variance with Pairwise Multiple Comparisons to indicate the relationships of the number of subjects in a group with the time required to reach a correct solution. The null hypothesis was further tested by group time to solution by using an Nth Order Correlation analysis.

> Null Hypothesis E: There is no significant difference between the number of subjects on a team and the time required to reach a correct solution. (Research Hypothesis: There is a curvilinear relationship between group size and time to solution.)

The results of these analyses are presented in Tables 15 and 16 and Figure 16. Data are presented separately for first, second, and third sessions.

An examination of Table 15 indicated that there were no significant differences in program one, but there were significant differences in programs two and three with the groups of five.

## TABLE 15

## UNIVARIATE ONE-WAY ANALYSIS OF VARIANCE OF TIME TO SOLUTION BY PROGRAM SESSION ON GROUP SIZE WHEN ALL PROGRAMS IN SERIES ARE SOLVED

### Time in First Program

| Source | DF | Sum of Squares | Mean Square | F-Statistic | Significance |
|---|---|---|---|---|---|
| Between | 3 | 348.55 | 116.180 | 1.8293 | .1578 |
| Within | 39 | 2477.00 | 65.513 | | |
| Total | 42 | 2825.60 | (RANDOM EFFECTS STATISTICS) | | |

ETA = .3512 ETA-SQR = .1234 (VAR COMP = 5.6432 % VAR AMONG = 8.16)

| Group Size | Subject N | Mean | Variance | Standard Dev. |
|---|---|---|---|---|
| One | 1 | 31.100 | | |
| Two | 10 | 30.540 | 105.870 | 10.2890 |
| Three | 12 | 25.675 | 20.986 | 4.5810 |
| Five | 20 | 23.600 | 68.068 | 8.2504 |
| Grand | 43 | 25.967 | 67.275 | 8.2021 |

| Pairwise Strata | Multiple Comparison Diff. | F-Stat. | Signif. | Scheffe Allowances Lev.=.95 | Lev.=.99 |
|---|---|---|---|---|---|
| One | | | | | |
| Two | 0.5600 | 0.00448 | .9469 | 24.4190 | 30.116 |
| Three | 5.4250 | 0.42774 | .5169 | 24.234 | 29.887 |
| Five | 7.5000 | 0.84347 | .3641 | 23.858 | 29.424 |
| Two | | | | | |
| Three | 4.8650 | 2.03260 | .1619 | 9.9692 | 12.295 |
| Five | 6.9400 | 5.05550 | .0303 | 9.0175 | 11.121 |
| Three | | | | | |
| Five | 2.0750 | 0.50843 | .4801 | 8.5017 | 10.485 |

### Time in Second Program

| Source | DF | Sum of Squares | Mean Square | F-Statistic | Significance |
|---|---|---|---|---|---|
| Between | 3 | 445.43 | 148.480 | 7.7507 | .0004 |
| Within | 39 | 747.11 | 19.157 | | |
| Total | 42 | 1192.50 | (RANDOM EFFECTS STATISTICS) | | |

ETA = .6112 ETA-SQR = .3735 (VAR COMP = 13.856 % VAR AMONG = 41.97)

TABLE 15 (continued)

| Group Size | Subject N | Mean | Variance | Standard Dev. |
|---|---|---|---|---|
| One | 1 | 22.000 | | |
| Two | 10 | 25.020 | 12.7480 | 3.5705 |
| Three | 12 | 25.550 | 46.2250 | 6.7989 |
| Five | 20 | 18.800 | 6.5211 | 2.5536 |
| Grand | 43 | 22.205 | 28.3940 | 5.3286 |

| Pairwise Strata | Multiple Comparison Diff. | F-Stat. | Signif. | Scheffe Allowances Lev.=.95 | Lev.=.99 |
|---|---|---|---|---|---|
| One | | | | | |
| Two | -3.0200 | 0.43282 | .5145 | 13.4110 | 16.5400 |
| Three | -3.5500 | 0.60726 | .4405 | 13.3090 | 16.4140 |
| Five | 3.2000 | 0.50909 | .4798 | 13.1030 | 16.1590 |
| Two | | | | | |
| Three | -0.5300 | 0.07998 | .7788 | 5.4750 | 6.7523 |
| Five | 6.2200 | 13.46400 | .0007 | 4.9524 | 6.1077 |
| Three | | | | | |
| Five | 6.7500 | 17.83800 | .0001 | 4.6691 | 5.7584 |

Time in Third Program

| Source | DF | Sum of Squares | Mean Square | F-Statistic | Significance |
|---|---|---|---|---|---|
| Between | 3 | 386.04 | 128.680 | 11.223 | .0000 |
| Within | 39 | 447.18 | 11.466 | | |
| Total | 43 | 833.22 | (RANDOM EFFECTS STATISTICS) | | |

ETA = .6807 ETA-SQR = .4633 (VAR COMP = 12.559 % VAR AMONG = 52.27)

| Group Size | Subject N | Mean | Variance | Standard Dev. |
|---|---|---|---|---|
| One | 1 | 27.300 | | |
| Two | 10 | 23.180 | 23.7130 | 4.8696 |
| Three | 12 | 21.950 | 16.3550 | 4.0442 |
| Five | 20 | 16.950 | 2.8342 | 1.6835 |
| Grand | 43 | 20.035 | 19.8390 | 4.4540 |

TABLE 15 (continued)

| Pairwise Strata | Multiple Diff. | Comparison F-Stat. | Signif. | Scheffe Allowances Lev.=.95 | Lev.=.99 |
|---|---|---|---|---|---|
| One | | | | | |
| Two | 4.1200 | 1.34580 | .2531 | 10.3760 | 12.7960 |
| Three | 3.3500 | 2.30430 | .1371 | 10.2970 | 12.6990 |
| Five | 10.3500 | 8.89770 | .0049 | 10.1370 | 12.5020 |
| Two | | | | | |
| Three | 1.2300 | 0.71971 | .4014 | 4.2358 | 5.2240 |
| Five | 6.2300 | 22.56700 | .0000 | 3.8314 | 4.7252 |
| Three | | | | | |
| Five | 5.0000 | 16.35300 | .0002 | 3.6123 | 4.4500 |

## TABLE 16

## Nth-ORDER CORRELATION OF TIME TO SOLUTION BY PROGRAM SESSION WITH GROUP SIZE WHEN ALL PROGRAMS IN SESSIONS ARE SOLVED

| | First Program N = 14 | Second Program N = 14 | Third Program N = 14 |
|---|---|---|---|
| Degree of Equation | 3 | 3 | 3 |
| Constant | 22.21200 | 13.51200 | 37.11200 |
| 1st Degree Coef. | 15.32500 | 11.80500 | -13.59290 |
| 2nd Degree Coef. | -7.29500 | -3.61000 | 4.24750 |
| 3rd Degree Coef. | 0.85700 | 0.29200 | -0.46708 |
| Coef. of Determination | 0.13990 | 0.36900 | 0.42470 |
| Coef. of Correlation | 0.37408 | 0.60780 | 0.65173 |
| Standard Error of Est. | 9.01000 | 4.10140 | 4.21200 |
| Sig. @ .05 | 0.51400 | 0.51400 | 0.51400 |
| Predicted Values | | | |
| Ones | 31.10000 | 21.99000 | 27.30000 |
| Twos | 30.54000 | 25.02000 | 23.17900 |
| Threes | 25.67500 | 24.32000 | 21.95000 |
| Fours | 21.64700 | 21.66700 | 20.81000 |
| Fives | 23.60000 | 18.80000 | 16.95000 |

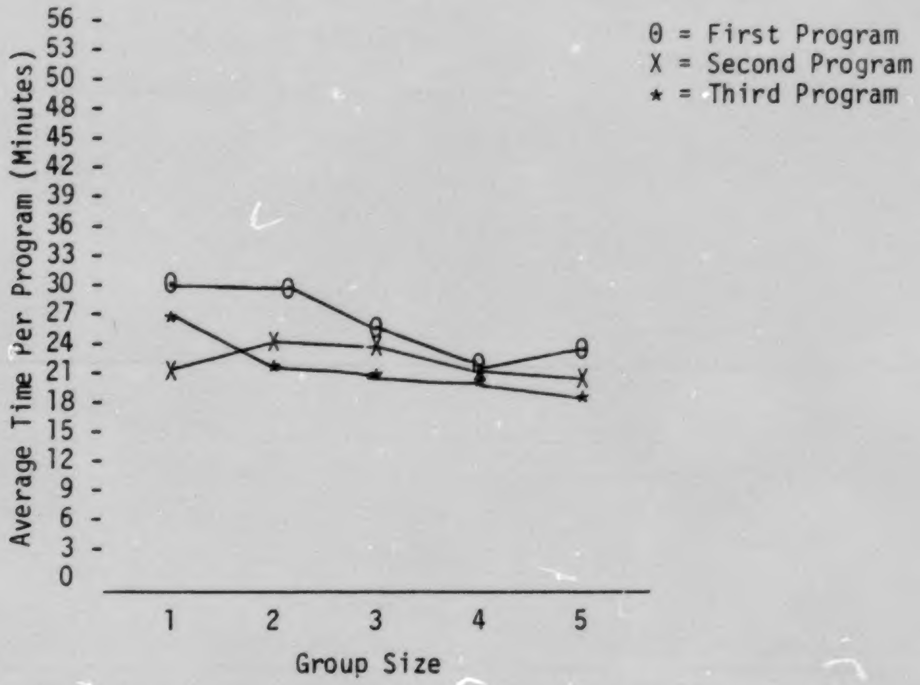


Figure 16. Nth-Order Regression Fit For Three Sequential Programs Over Time When All Programs in Series Are Solved

The means, variances and standard deviations for groups of five in programs two and three were considerably less indicating not only greater achievement but also greater consistency. These differences were also within the more rigorous Scheffe allowances. Therefore the null hypothesis was rejected.

An examination of Table 16 indicated a significant correlation at the .05 level for the second and third programs, supporting the results in the ANOVA analysis in Table 15. The predicted values for the group sizes are graphed in Figure 16 indicating curvilinear relationships which support the research hypothesis.

These results indicated that individuals working alone (ones) did not consistently improve in time needed for solution. Teams of two, three and five subjects did consistently improve their time with teams of five showing the best time. It would appear that the larger the group (up to five), the more efficient the problem-solvers. However, the reader must keep in mind that the data in Figure 16 does not reflect individual input and effort and that observations delineated in Chapter III detail environmental and social constraints in larger groups. These conclusions point toward a need for more study.

### Null Hypothesis F

Null Hypothesis F was tested by using a Univariate 1-Way Analysis of Variance and results were supported by a frequency bar graph describing the relationship of the number of subjects in a group and the achievement of a correct solution.

> Null Hypothesis F: There is no significant difference in the number of subjects in a group and the achievement of a correct solution as measured by the number of programs solved. (Research Hypothesis: There is a curvilinear relationship between group size and achieving a correct solution.)

The analysis comparing problems solved by group size is presented in Table 17. An examination of Table 17 indicated significant differences by group size. The mean number of programs solved for individuals was much less than for groups. The pairwise multiple comparisons clearly indicated significant differences between the individual working alone and any size team. The frequency distribution of problems solved by group size is presented in Figure 17.

### TABLE 17

### UNIVARIATE ONE-WAY ANALYSIS OF VARIANCE OF THE NUMBER OF PROGRAMS SOLVED BY GROUP SIZE

| Source | DF | Sum of Squares | Mean Square | F-Statistic | Significance |
|---|---|---|---|---|---|
| Between | 3 | 10.000 | 3.3333 | 6.7760 | .0005 |
| Within | 62 | 30.500 | 0.49194 | | |
| Total | 65 | 40.500 | (RANDOM EFFECTS STATISTICS) | | |

ETA = .4969 ETA-SQR = .2469 (VAR COMP = .19058 % VAR AMONG = 27.92)

| Group Size | Subject N | Mean | Variance | Standard Dev. |
|---|---|---|---|---|
| One | 6 | 2.3333 | 1.4667 | 1.2111 |
| Two | 12 | 3.8333 | 0.15152 | 0.38925 |
| Three | 18 | 3.6667 | 0.23529 | 0.48507 |
| Five | 30 | 3.5000 | 0.60345 | 0.77682 |
| Grand | 66 | 3.5000 | 0.62308 | 0.78935 |

| Pairwise Strata | Multiple Comparison Diff. | Multiple Comparison F-Stat. | Signif. | Scheffe Allowances Lev.=.95 | Scheffe Allowances Lev.-.99 |
|---|---|---|---|---|---|
| One | | | | | |
| Two | -1.5000 | 18.295 | .0001 | 1.0078 | 1.2320 |
| Three | -1.3333 | 16.262 | .0002 | 0.95019 | 1.1616 |
| Five | -1.1667 | 13.834 | .0004 | 0.90143 | 1.1020 |
| Two | | | | | |
| Three | 0.16667 | 0.40656 | .5261 | 0.75119 | 0.91831 |
| Five | 0.33333 | 1.9360 | .1691 | 0.68848 | 0.84165 |
| Three | | | | | |
| Five | 0.16667 | 0.63525 | .4285 | 0.60095 | 0.73465 |

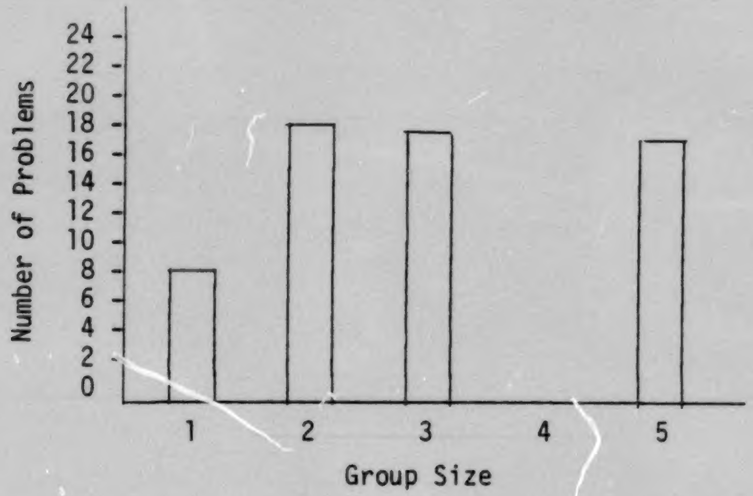


Figure 17. Frequency Distribution of Programs Solved by Group Size

An examination of Figure 17 indicated there is a definite curvilinear relationship supporting the research hypothesis. This bar graph clearly showed that subjects working in groups did significantly better than subjects working alone. Therefore the null hypothesis was rejected and the research hypothesis was supported.

A further examination of means, variances, standard deviations and frequency distributions indicated a tendency for smaller teams to solve more programs with more consistency than larger teams. While these were not significant differences, these observations would support the caution in the interpretation of data in Table 15 and Figure 16. Teams of five may take less time to solve a program but they solved fewer programs.

Null Hypothesis G

Null Hypothesis G was tested by using Univariate 1-Way Analysis of Variance with pairwise multiple comparisons and frequency bar graphs to analyze the level of program difficulty of the six sequential orders of programs. By so doing the variation of individual program difficulty could be determined.

> Null Hypothesis G: There is no significant difference in the order of difficulty of the three microcomputer programs when presented in random order. (Research Hypothesis: The three programs are of approximately equal difficulty.)
>
> > Sub $H_0$ G1: There is no significant difference when measured by the number of programs solved.
> >
> > Sub $H_0$ G2: There is no significant difference when measured by time to solution.
> >
> > Sub $H_0$ G3: There is no significant difference when measured by the number of clues required for solution.

Program difficulty can be measured by three types of observations: number of programs solved ($H_0$ G1), time to solution ($H_0$ G2), and number of clues needed for solution ($H_0$ G3). An analysis of each factor was felt to be an important contribution to a composite evaluation of the variation of program difficulty. The results of these analyses are presented in Tables 18, 19, and 20 and Figures 18 and 19.

An examination of Table 18 indicated that there were significant differences between the program sequences. An examination of the pairwise multiple comparisons indicated that sequence D ("Vertebrate Pets"; "Global Travelers"; "Energy at Home") had significantly fewer programs solved than sequences A, C, E, and F but not B.

## TABLE 18

## UNIVARIATE ONE-WAY ANALYSIS OF VARIANCE OF THE NUMBER OF PROGRAMS SOLVED WITHIN THE SIX SEQUENTIAL ORDERS OF PROGRAMS

| Source | DF | Sum of Squares | Mean Square | F-Statistic | Significance |
|---|---|---|---|---|---|
| Between | 5 | 13.409 | 2.6818 | 5.9396 | .0002 |
| Within | 60 | 27.091 | 0.45152 | | |
| Total | 65 | 40.500 | (RANDOM EFFECTS STATISTICS) | | |

ETA = .5754 ETA-SQR = .3311 (VAR COMP = .20275 % VAR AMONG = 30.99)

| Sequence Order | N | Mean | Variance | Standard Dev. |
|---|---|---|---|---|
| A (E, V, G)* | 11 | 3.7273 | 0.21818 | 0.46710 |
| B (E, G, V) | 11 | 3.1818 | 0.16364 | 0.40452 |
| C (V, E, G) | 11 | 3.9091 | 0.09091 | 0.30151 |
| D (V, G, E) | 11 | 2.6364 | 1.0545 | 1.0269 |
| E (G, E, V) | 11 | 3.7273 | 0.81818 | 0.90453 |
| F (G, V, E) | 11 | 3.8182 | 0.36364 | 0.60302 |
| Grand | 66 | 3.5000 | 0.62308 | 0.78935 |

| Pairwise Strata | Multiple Comparison Dif. | F-Stat. | Signif. | Scheffe Allowances Lev.=.95 | Lev.=.99 |
|---|---|---|---|---|---|
| A | | | | | |
| B | 0.54545 | 3.6242 | .0617 | .98585 | 1.1707 |
| C | -0.18182 | 0.40268 | .5281 | .98585 | 1.1707 |
| D | 1.0909 | 14.497 | .0003 | .98585 | 1.1707 |
| E | 0.0 | 0.0 | 1.0000 | .98585 | 1.1707 |
| F | -0.09091 | 0.10067 | .7521 | .98585 | 1.1707 |
| B | | | | | |
| C | -0.72727 | 6.4430 | .0138 | .98585 | 1.1707 |
| D | 0.54545 | 3.6242 | .0617 | .98585 | 1.1707 |
| E | -0.54545 | 3.6242 | .0617 | .98585 | 1.1707 |
| F | -0.63636 | 4.9329 | .0301 | .98585 | 1.1707 |
| C | | | | | |
| D | 1.2727 | 19.732 | .0000 | .98585 | 1.1707 |
| E | 0.18182 | 0.40268 | .5281 | .98585 | 1.1707 |
| F | 0.09091 | 0.10067 | .7521 | .98585 | 1.1707 |
| D | | | | | |
| E | -1.0909 | 14.497 | .0003 | .98585 | 1.1707 |
| F | -1.1818 | 17.013 | .0001 | .98585 | 1.1707 |
| E | | | | | |
| F | -0.09091 | 0.10067 | .7521 | .98585 | 1.1707 |

*E=Energy at Home V=Vertebrate Pets G=Global Travelers

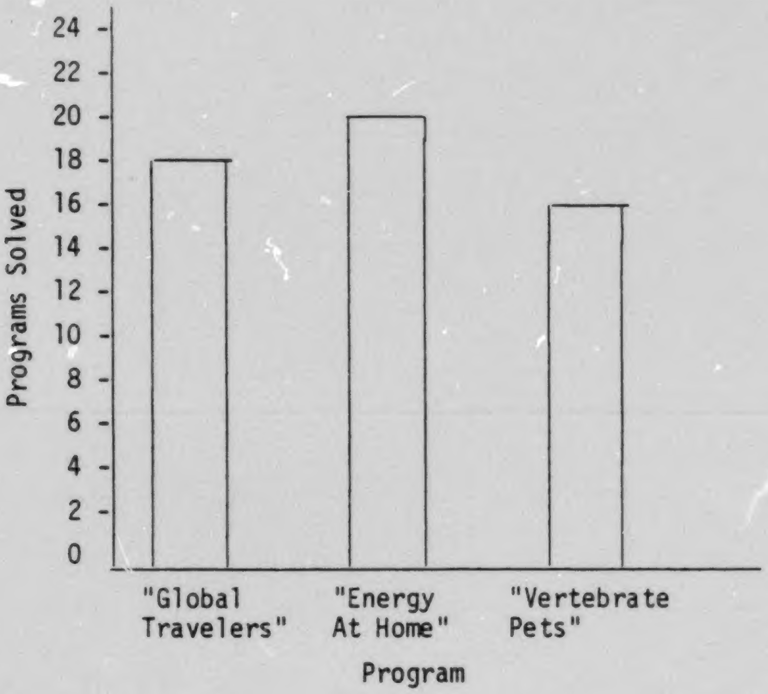


Figure 18. Frequency Distribution of Programs Solved by Individual Program

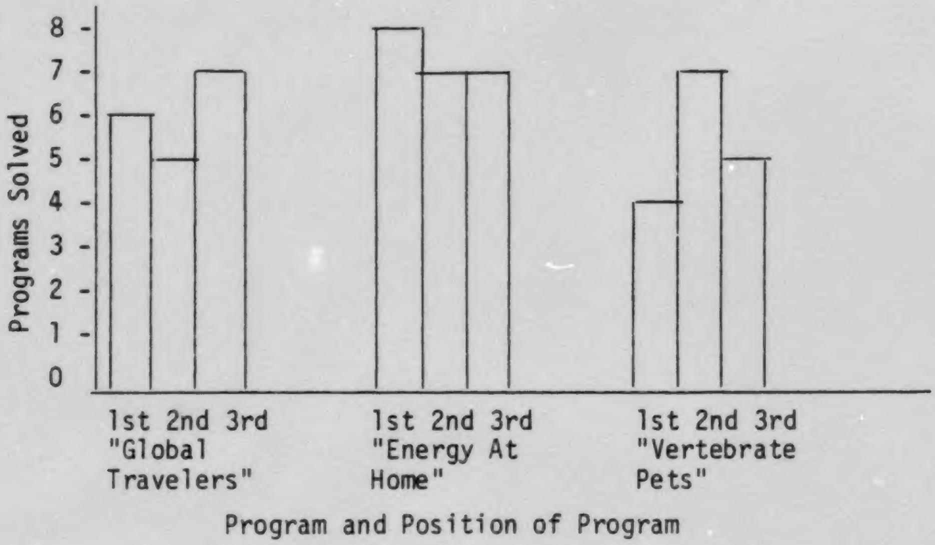


Figure 19. Frequency Distribution of the Number of Programs Solved by Program and Position of Program in Series

## TABLE 19

### UNIVARIATE ONE-WAY ANALYSIS OF VARIANCE OF TIME TO SOLUTION WITHIN THE SIX SEQUENTIAL ORDERS OF PROGRAMS WHEN ALL PROGRAMS IN SERIES WERE SOLVED

First Program

| Source | DF | Sum of Squares | Mean Squares | F-Statistic | Significance |
|---|---|---|---|---|---|
| Between | 5 | 2422.6 | 484.52 | 44.490 | .0000 |
| Within | 37 | 402.95 | 10.890 | | |
| Total | 42 | 2825.6 | (RANDOM EFFECTS STATISTICS) | | |

ETA = .9260 ETA-SQR - .8574 (VAR COMP = 69.178 % VAR AMONG = 86.40)

| Sequence Order | N | Mean | Variance | Standard Dev. |
|---|---|---|---|---|
| A (E, V, G)* | 8 | 33.637 | 11.051 | 3.3243 |
| B (E, G, V) | 2 | 39.000 | 0.0 | 0.0 |
| C (V, E, G) | 10 | 30.220 | 10.448 | 3.2324 |
| D (V, G, E) | 3 | 29.000 | 0.0 | 0.0 |
| E (G, E, V) | 10 | 23.690 | 2.2388 | 1.4963 |
| F (G, V, E) | 10 | 14.340 | 23.489 | 4.8466 |
| Grand | 43 | 25.967 | 67.275 | 8.2021 |

| Pairwise | Multiple Comparison | | | Scheffe Allowances | |
|---|---|---|---|---|---|
| Strata | Diff. | F-Stat. | Signif. | Lev.=.95 | Lev.=.99 |
| A | | | | | |
| B | -5.3625 | 4.2248 | .0469 | 9.1678 | 11.004 |
| C | 3.4175 | 4.7664 | .0354 | 5.5007 | 6.6023 |
| D | 4.6375 | 4.3086 | .0449 | 7.8509 | 9.4232 |
| E | 9.9475 | 40.383 | .0000 | 5.5007 | 6.6023 |
| F | 19.297 | 151.98 | .0000 | 5.5007 | 6.6023 |
| B | | | | | |
| C | 8.7800 | 11.798 | .0015 | 8.9826 | 10.782 |
| D | 10.000 | 11.019 | .0020 | 10.586 | 12.706 |
| E | 15.310 | 35.872 | .0000 | 8.9826 | 10.782 |
| F | 24.660 | 93.065 | .0000 | 8.9826 | 10.782 |
| C | | | | | |
| D | 1.2200 | 0.31539 | .5778 | 7.6337 | 9.1626 |
| E | 6.5300 | 19.577 | .0001 | 5.1861 | 6.2247 |
| F | 15.880 | 115.78 | .0000 | 5.1861 | 6.2247 |
| D | | | | | |
| E | 5.3100 | 5.9748 | .0194 | 7.6337 | 9.1626 |
| F | 14.660 | 45.541 | .0000 | 7.6337 | 9.1626 |
| E | | | | | |
| F | 9.3500 | 40.137 | .0000 | 5.1861 | 6.2247 |

*E="Energy at Home V="Vertebrate Pets" G="Global Travelers"

TABLE 19 (continued)

Second Program

| Source | DF | Sum of Squares | Mean Squares | F-Statistic | Significance |
|---|---|---|---|---|---|
| Between | 5 | 55.92 | 110.38 | 6.3753 | .0002 |
| Within | 37 | 640.62 | 17.314 | | |
| Total | 42 | 1192.5 | (RANDOM EFFECTS STATISTICS) | | |

ETA = .6803 ETA-SQR = .4628 (VAR COMP = 13.594 % VAR AMONG = 43.98)

| Sequence Order | N | Mean | Variance | Standard Dev. |
|---|---|---|---|---|
| A | 8 | 21.475 | 6.4450 | 2.5387 |
| B | 2 | 27.200 | 0.0 | 0.0 |
| C | 10 | 27.320 | 39.684 | 6.2995 |
| D | 3 | 25.000 | 0.0 | 0.0 |
| E | 10 | 19.720 | 13.148 | 3.6261 |
| F | 10 | 18.320 | 13.335 | 3.6517 |
| Grand | 43 | 22.205 | 28.394 | 5.3286 |

| Pairwise | Multiple Comparison | | | Scheffe Allowances | |
|---|---|---|---|---|---|
| Strata | Diff. | F-Stat. | Signif. | Lev.=.95 | Lev.=.99 |
| A | | | | | |
| B | -5.7250 | 3.0288 | .0901 | 11.560 | 13.875 |
| C | -5.8450 | 8.7697 | .0053 | 6.9358 | 8.3248 |
| D | -3.5250 | 1.5658 | .2187 | 9.8991 | 11.882 |
| E | 1.7550 | 0.79063 | .3797 | 6.9358 | 8.3248 |
| F | 3.1550 | 2.5551 | .1184 | 6.9358 | 8.3248 |
| B | | | | | |
| C | -0.12000 | 0.001386 | .9705 | 11.326 | 13.594 |
| D | 2.2000 | 0.33545 | .5660 | 13.348 | 16.021 |
| E | 7.4800 | 5.3858 | .0259 | 11.326 | 13.594 |
| F | 8.8800 | 7.5906 | .0090 | 11.326 | 13.594 |
| C | | | | | |
| D | 2.3200 | 0.71739 | .4024 | 9.6253 | 11.553 |
| E | 7.6000 | 16.680 | .0002 | 6.5391 | 7.8487 |
| F | 9.0000 | 23.391 | .0000 | 6.5391 | 7.8487 |
| D | | | | | |
| E | 5.2800 | 3.7157 | .0616 | 9.6253 | 11.553 |
| F | 6.6800 | 5.9474 | .0197 | 9.6253 | 11.553 |
| E | | | | | |
| F | 1.4000 | 0.56601 | .4566 | 6.5391 | 7.8487 |

TABLE 19 (continued)

Third Program

| Source | DF | Sum of Squares | Mean Squares | F-Statistic | Significance |
|---|---|---|---|---|---|
| Between | 5 | 219.48 | 43.896 | 2.6463 | .0383 |
| Within | 37 | 613.74 | 16.587 | | |
| Total | 42 | 833.22 | (RANDOM EFFECTS STATISTICS) | | |

ETA = .5132 ETA-SQR = .2634 (VAR COMP = 3.9887 % VAR AMONG = 19.39)

| Sequence Order | N | Mean | Variance | Standard Dev. |
|---|---|---|---|---|
| A | 8 | 22.850 | 24.466 | 4.9463 |
| B | 2 | 15.600 | 0.00000 | 0.00000 |
| C | 10 | 19.260 | 5.2960 | 2.3013 |
| D | 3 | 25.200 | 0.0 | 0.0 |
| E | 10 | 18.340 | 15.909 | 3.9887 |
| F | 10 | 19.590 | 27.959 | 5.2876 |
| Grand | 43 | 20.035 | 19.839 | 4.4540 |

| Pairwise Strata | Multiple Comparison Diff. | F-Stat. | Signif. | Scheffe Allowances Lev.=.95 | Lev.=.99 |
|---|---|---|---|---|---|
| A | | | | | |
| B | 7.2500 | 5.0701 | .0304 | 11.314 | 13.580 |
| C | 3.5900 | 3.4532 | .0711 | 6.7887 | 8.1483 |
| D | -2.3500 | 0.72640 | .3995 | 9.6891 | 11.630 |
| E | 4.5100 | 5.4499 | .0278 | 6.7887 | 8.1483 |
| F | 3.2600 | 2.8476 | .0999 | 6.7887 | 8.1483 |
| B | | | | | |
| C | -3.6600 | 1.3460 | .2534 | 11.086 | 13.306 |
| D | -9.6000 | 6.6672 | .0139 | 13.065 | 15.681 |
| E | -2.7400 | 0.75434 | .3907 | 11.086 | 13.306 |
| F | -3.9900 | 1.5996 | .2139 | 11.086 | 13.306 |
| C | | | | | |
| D | -5.9400 | 4.9087 | .0330 | 9.4212 | 11.308 |
| E | 0.92000 | 0.25513 | .6165 | 6.4004 | 7.6822 |
| F | -0.33000 | 0.03283 | .8572 | 6.4004 | 7.6822 |
| D | | | | | |
| E | 6.8600 | 6.5470 | .0147 | 9.4212 | 11.308 |
| F | 5.6100 | 4.3785 | .0433 | 9.4212 | 11.308 |
| E | | | | | |
| F | -1.2500 | 0.47099 | .4968 | 6.4004 | 7.6822 |

## TABLE 20

## UNIVARIATE ONE-WAY ANALYSIS OF VARIANCE OF CLUES NEEDED FOR SOLUTION WITHIN THE SIX SEQUENTIAL ORDERS OF PROGRAMS WHEN ALL PROGRAMS IN SERIES WERE SOLVED

### First Program

| Source | DF | Sum of Squares | Mean Squares | F-Statistic | Significance |
|---|---|---|---|---|---|
| Between | 5 | 3007.1 | 601.41 | 7.8133 | .0000 |
| Within | 37 | 2848.0 | 76.973 | | |
| Total | 42 | 5855.1 | (RANDOM EFFECTS STATISTICS) | | |

ETA = .7166 ETA-SQR = .5136 (VAR COMP = 76.600 % VAR AMONG = 49.88)

| Sequence Order | N | Mean | Variance | Standard Dev. |
|---|---|---|---|---|
| A | 8 | 33.750 | 263.36 | 16.228 |
| B | 2 | 38.000 | 0.0 | 0.0 |
| C | 10 | 35.300 | 38.233 | 6.1833 |
| D | 3 | 23.000 | 0.0 | 0.0 |
| E | 10 | 32.000 | 43.333 | 6.5828 |
| F | 10 | 14.600 | 30.044 | 5.4813 |
| Grand | 43 | 28.698 | 139.41 | 11.807 |

| Pairwise Strata | Multiple Comparison Diff. | F-Stat. | Signif. | Scheffe Allowances Lev.=.95 | Lev.=.99 |
|---|---|---|---|---|---|
| A | | | | | |
| B | -4.2500 | 0.37546 | .5438 | 24.373 | 29.254 |
| C | -1.5500 | 0.13872 | .7117 | 14.624 | 17.553 |
| D | 10.750 | 3.2756 | .0784 | 20.872 | 25.052 |
| E | 1.7500 | 0.17683 | .6765 | 14.624 | 17.553 |
| F | 19.150 | 21.175 | .0000 | 14.624 | 17.553 |
| B | | | | | |
| C | 2.7000 | 0.15785 | .6934 | 23.881 | 28.663 |
| D | 15.000 | 3.5077 | .0690 | 28.144 | 33.780 |
| E | 6.0000 | 0.77949 | .3830 | 23.881 | 28.663 |
| F | 23.400 | 11.856 | .0014 | 23.881 | 28.663 |
| C | | | | | |
| D | 12.300 | 4.5358 | .0399 | 20.295 | 24.359 |
| E | 3.3000 | 0.70739 | .4057 | 13.788 | 16.549 |
| F | 20.700 | 27.834 | .0000 | 13.788 | 16.549 |
| D | | | | | |
| E | -9.0000 | 2.4284 | .1277 | 20.295 | 24.359 |
| F | 8.4000 | 2.1154 | .1543 | 20.295 | 24.359 |
| E | | | | | |
| F | 17.400 | 19.667 | .0001 | 13.788 | 16.549 |

TABLE 20 (continued)

### Second Program

| Source | DF | Sum of Squares | Mean Squares | F-Statistic | Significance |
|---|---|---|---|---|---|
| Between | 5 | 261.41 | 52.282 | 0.93492 | .4698 |
| Within | 37 | 2069.1 | 55.922 | | |
| Total | 42 | 2330.5 | | | |

(RANDOM EFFECTS STATISTICS)

ETA = .3349 ETA-SQR = .1122 (VAR COMP = -0.53155 % VAR AMONG = -0)

| Sequence Order | N | Mean | Variance | Standard Dev. |
|---|---|---|---|---|
| A | 8 | 27.000 | 13.714 | 3.7033 |
| B | 2 | 28.000 | 0.0 | 0.0 |
| C | 10 | 25.500 | 35.833 | 5.9861 |
| D | 3 | 26.000 | 0.0 | 0.0 |
| E | 10 | 20.500 | 22.500 | 4.7434 |
| F | 10 | 25.700 | 160.90 | 12.685 |
| Grand | 43 | 24.814 | 55.488 | 7.4491 |

(Since the Analysis of this program was not significant, the pairwise comparisons are not included.)

### Third Program

| Source | DF | Sum of Squares | Mean Squares | F-Statistic | Significance |
|---|---|---|---|---|---|
| Between | 5 | 207.54 | 41.507 | .42208 | .8303 |
| Within | 37 | 3639.0 | 98.351 | | |
| Total | 42 | 3846.5 | | | |

(RANDOM EFFECTS STATISTICS)

ETA = .2323 ETA-SQR = .0540 (VAR COMP = -8.3025 % VAR AMONG = -0)

| Sequence Order | N | Mean | Variance | Standard Dev. |
|---|---|---|---|---|
| A | 8 | 25.375 | 335.41 | 18.314 |
| B | 2 | 22.000 | 0.0 | 0.0 |
| C | 10 | 19.700 | 0.67778 | 0.82327 |
| D | 3 | 20.000 | 0.0 | 0.0 |
| E | 10 | 20.100 | 64.544 | 8.0340 |
| F | 10 | 23.300 | 78.233 | 8.8450 |
| Grand | 43 | 21.814 | 91.584 | 9.5699 |

(Since the Analysis on this program was not significant, the pairwise comparisons are not included.)

An examination of Figure 18 indicated that "Vertebrate Pets" had the least solved, "Global Travelers" had more solved, and "Energy at Home" had the most programs solved. Sequence D followed the same order of decreasing difficulty with the least number of solved programs first.

An examination of Figure 19 provided further evidence that the programs did vary depending on their position in the sequence.

In Table 19 analysis of data for time to solution is presented for each of the three program positions: first, second, and third. Only data were included for sessions in which all programs were solved. Scheffe allowances were used as a criteria for .05 significance. An examination of the analysis indicated that in session one, "Global Travelers" (sequence E and F) required significantly less time than sequences A, B, C, and D. In session two "Vertebrate Pets" (sequence F) and "Energy at Home" (sequence E) required significantly less time than "Global Travelers" in sequence C. In session three there were no significant differences when using the more rigorous Scheffe allowances.

An examination of the analysis of the clues needed in each of the program positions in Table 20 indicated that there were significant results only in the first session. In session one "Global Travelers" (sequence F) required significantly fewer clues than programs in sequences A, C, and E. These results were not consistent for the specific program since sequences E and F both began with "Global Travelers." It should be noted that in programs two and three, the variances and standard deviations were very large indicating a lack of consistent use of clues.

These three tests would indicate that within the sequence series there were some significant differences in programs solved and time and clues required. However, these were not consistent as was pointed out in the analysis of clues. Also noted were the variations in numbers of problems solved. The N is so small in some cases that valid conclusions could not be drawn on the basis of time and clues for programs solved. However, the evidence suggested that Sequence F (G.T., V.P., E.H.) may be easier but further study would have to be made with a larger sample to support this. Since there were significant differences noted, the null hypothesis was rejected.

### Null Hypothesis H

Null Hypothesis H was tested using three measures: Chi Square Test, Kolmogorov-Smirnov 2-Sample Test, and T-Tests. These tests compared observed values of achievement on a daily session basis and a once-a-week basis with expected values. Two types of observations were used for achievement data in this hypothesis: the number of programs solved and the time required to solve each program.

> Null Hypothesis H: There is no significant difference between the achievement of groups who attempt to solve problems on three consecutive days and those groups who attempt to solve problems on a once-a-week basis. (Research Hypothesis: Daily problem-solvers will show greater achievement.)
>
> Sub $H_0$ H1: There is no significant difference when measured by number of programs solved.
>
> Sub $H_0$ H2: There is no significant difference when measured by the time needed for solution.

The results for the analysis of programs solved ($H_0$ H1) with session frequency are presented in Tables 21 and 22. An examination of the results of the Chi Square test in Table 21 indicated no significant differences. As a further test of goodness of fit for a smaller N, the Kolmogorov-Smirnov 2-Sample test was used and presented in Table 22. An examination of this table showed no significant differences.

### TABLE 21

### CHI SQUARE TEST FOR DIFFERENCES IN NUMBER OF PROGRAMS SOLVED BY GROUPS BY SESSION WHEN SOLVED EVERY DAY AND ONCE-A-WEEK

| | Every Day | Once-a-Week |
|---|---|---|
| First Program Solved | 10 | 8 |
| Second Program Solved | 12 | 7 |
| Third Program Solved | 10 | 9 |

| Column | Observed Value | Expected Value | Chi Square Contribution |
|---|---|---|---|
| 1 | 10 | 10.29 | .008 |
| | 12 | 10.86 | .120 |
| | 10 | 10.86 | .068 |
| 2 | 8 | 7.71 | .011 |
| | 7 | 8.14 | .160 |
| | 9 | 8.14 | .090 |

Chi Square = .457 DF = 2 Sig. @ .796

TABLE 22

KOLMOGOROV-SMIRNOV 2-SAMPLE TEST OF DIFFERENCES IN THE NUMBER OF PROGRAMS SOLVED BY GROUP BY SESSION WHEN SOLVED EVERY DAY AND ONCE-A-WEEK

| | Every Day | Once-a-Week |
|---|---|---|
| First Program Solved | 10 | 8 |
| Second Program Solved | 12 | 7 |
| Third Program Solved | 10 | 9 |

N of x = 32 Cum. Difference = .020833 D Max. = .0625
N of y = 24 Cum. Difference = .0625 Sig. @ 1.7968
Cum. Difference = 0

The results for the analysis of time required to solve programs and the session frequency are presented in Table 23.

TABLE 23

T-TEST BY GROUP OF AVERAGE TIME TO SOLUTION WITH FREQUENCY OF SESSIONS BY POSITION OF PROGRAM IN SERIES

| | First Program | | Second Program | | Third Program | |
|---|---|---|---|---|---|---|
| Measures | Every Day | Once-a Week | Every Day | Once-a Week | Every Day | Once-a Week |
| N | 10 | 8 | 12 | 7 | 10 | 9 |
| $\bar{X}$ | 26.84 | 29.42 | 21.34 | 24.19 | 21.14 | 22.42 |
| S.D. | 5.6 | 9.08 | 2.7 | 6.5 | 4.5 | 7.3 |
| T | -0.742 | | -1.35 | | -0.47 | |
| DF | 16 | | 17 | | 17 | |
| Sig. @ | .53 | | .19 | | .65 | |

An examination of the three T-Tests in Table 23 indicated no significant differences. As was discovered in Hypothesis C, differences did exist in frequency of session as regards use of a matrix strategy but not in achievement or in time needed. On the basis of these three tests of significance, the null hypothesis could not be rejected, but the research hypothesis was rejected.

## Questions of True Interest

Since this is an exploratory study in a new field of technological adaptation, all variables and hypotheses of interest were not anticipated. In the course of this study questions of true interest surfaced and were considered. One question concerned the order and categories of clues requested by the subjects while playing the programs. Another was a quest for all possible interactions that may not have been foreseen. These two concerns will be addressed below.

### The Clues

During the program sessions the data-saving statements in the microcomputer programs recorded the order and category of clues requested by the subjects. It would seem that an analysis of such a listing might reveal information as to the strategy used by the subjects. There were some inherent difficulties in analyzing team effort. Sixty of the subjects did not work individually but in teams. Teams had a variety of ways of choosing clues. Some had a dominant individual who controlled clue choice, others gave each team member a turn and often an individual choice did not relate to previous choices by teammates. In search of a pattern, all clues for all sessions for "Energy at Home" were listed and compared, but no apparent pattern emerged. Therefore, that analytic strategy was discarded.

A more productive analysis was considered concerning the number of times the subjects changed category choice within a given program. This might have indicated satisfaction or dissatisfaction with the current strategy and perhaps more consistency would correlate with efficient problem-solving. A summary of the number of category changes by program name, position of program in the sequence and group size are presented in Table 24.

An examination of Table 24 indicated a wide range of category changes; from no changes to thirty-nine changes. Students who gave up and did not solve the program problem exhibited a wider range of changes. Enough evidence emerged to warrant further investigation and analysis.

A null hypothesis was generated and five variables were considered in analyzing category change: (1) the position of the solved program in the series, (2) the change, if any, as each successive program is solved, (3) group size, (4) time required for solution, and (5) total number of clues needed for solution.

> Null Hypothesis I: There are no significant differences in the number of category changes in clue choices as measured by:
>
> (1) the position of any solved program,
> (2) successive programs solved,
> (3) group size,
> (4) time to solution, and
> (5) number of clues needed for solution.

TABLE 24

SUMMARY OF CLUE CHOICE CATEGORY CHANGES BY GROUP SIZE, PROGRAM, AND PROGRAM SEQUENCE

| Group Size | "Energy at Home" | "Vertebrate Pets" | "Global Travelers" |
|---|---|---|---|
| | First Program | First Program | First Program |
| 1 | 8, 15 | ⑯, ② | ㊴, ㉘ |
| 2 | 19, 18 | 29, ⑦ | 14, 3 |
| 3 | 12, 16 | 17, 2 | 16, 11 |
| 5 | 10, 8 | 21, ⑥ | 13, 9 |
| | Second Program | Second Program | Second Program |
| 1 | 1, ⑰ | 3, ⑭ | 12, ⓪ |
| 2 | 15, 10 | 7, 0 | 11, 20 |
| 3 | 10, 14 | 8, 18 | 7, 1 |
| 5 | 7, 1 | 10, 10 | ⑩, ⑨ |
| | Third Program | Third Program | Third Program |
| 1 | ②, 17 | ⑬, ⑭ | 8, 0 |
| 2 | 7, 0 | 8, 0 | 10, 7 |
| 3 | 0, 14 | ⑧, 10 | ⑧, 0 |
| 5 | 0, 14 | 4, 0 | 7, 0 |

○ = subjects did not solve problem

Gave up, range = 0-39

Solved, range = 0-29

Null Hypothesis I was tested by using 1-Way ANOVAs, Matched ANOVAs, T-Tests, Matched T-Tests and correlation R-Plots. The results for the analysis of $H_o$ II are presented in Tables 25 and 26. All solved programs were included.

TABLE 25

UNIVARIATE ONE-WAY ANALYSIS OF VARIANCE OF GROUP CHANGE OF CATEGORY OF CLUE CHOICE BY PROGRAM USING ALL-SOLVED PROGRAMS

| Group | N | Mean | Standard Deviation |
|---|---|---|---|
| First Program | 18 | 13.278 | 6.614 |
| Second Program | 19 | 8.684 | 5.774 |
| Third Program | 19 | 5.579 | 5.68 |

| Source | DF | Sum of Squares | Mean Squares | F-Statistic | Significance |
|---|---|---|---|---|---|
| Between | 2 | 553.009 | 276.505 | 7.615 | .001 |
| Within | 53 | 1924.348 | 36.308 | | |
| Total | 55 | 2477.357 | | ETA-SQR - .223 | |

TABLE 26

T-TESTS OF GROUP CHANGE OF CATEGORIES OF CLUE CHOICE BY PROGRAM USING ALL-SOLVED PROGRAMS

| | Programs | | | | | |
|---|---|---|---|---|---|---|
| Measures | First | Second | Second | Third | First | Third |
| N | 18 | 19 | 19 | 19 | 18 | 19 |
| $\bar{X}$ | 13.278 | 8.684 | 8.684 | 5.579 | 13.278 | 5.579 |
| S.D. | 6.614 | 5.774 | 5.774 | 5.68 | 6.614 | 5.68 |
| Diff. | 4.594 | | 3.105 | | 7.699 | |
| T | 2.2541 | | 1.671 | | 3.805 | |
| DF | 35 | | 36 | | 35 | |
| Sig. @ | .028 | | .099 | | .0008 | |

An examination of Table 25 indicated that the number of changes in categories declined significantly from the first program to the third program. An examination of the three T-Tests in Table 26 indicated that the significant differences were from program one to two and from program one to three. There were no significant differences from program two to three. It should be noted that similar significant results were reported in Hypothesis A when analyzing differences in time to solution. On the basis of these tests the null hypothesis was rejected.

The second part of the null hypothesis ($H_o$ I2) was tested by using a matched ANOVA and matched T-Tests to compare the category changes with successive programs in series where all programs were solved. Since the same groups were used for each successive program, the matched tests provided a more accurate analysis. The results of these analyses are presented in Tables 27 and 28.

TABLE 27

MATCHED ANALYSIS OF VARIANCE OF GROUP CHANGE OF CATEGORY OF CLUE CHOICE IN SUCCESSIVE PROGRAMS USING SERIES OF ALL-SOLVED PROGRAMS

| Group | Mean | Standard Deviation |
|---|---|---|
| First | 13.5714 | 7.219 |
| Second | 8.357 | 5.527 |
| Third | 5.5714 | 5.431 |

| Source | DF | Sum of Squares | Mean Squares | F Value | Significance |
|---|---|---|---|---|---|
| Rows | 13 | 869.83 | 66.910 | 2.957 | @ .05=2.125 |
| Groups | 2 | 461.76 | 230.880 | 10.205 | @ .05=3.37 |
| Int. Act. | 26 | 588.238 | 22.625 | | |
| Total | 41 | 1919.83 | | | |

TABLE 28

MATCHED T-TESTS OF THE GROUP CHANGE OF CATETORY
OF CLUE CHOICE IN SUCCESSIVE PROGRAMS USING ONLY
SERIES OF ALL-SOLVED PROGRAMS

| | Programs | | | | | |
|---|---|---|---|---|---|---|
| Measures | First | Second | Second | Third | First | Third |
| N | 14 | 14 | 14 | 14 | 14 | 14 |
| $\bar{X}$ | 13.5714 | 8.357 | 8.357 | 5.5714 | 13.5714 | 5.571 |
| S.D. | 7.219 | 5.527 | 5.527 | 5.431 | 7.219 | 5.431 |
| T Value | 3.139 | | 2.147 | | 3.4906 | |
| DF | 13 | | 13 | | 13 | |
| Sig. @ .05 | 2.160 | | 2.160 | | 2.160 | |
| @ .01 | 3.012 | | 3.012 | | 3.012 | |

An examination of Table 27 indicated that the F value is higher than the non-matched ANOVA in Table 25 and the number of category changes declined significantly at both the .05 and .01 levels. An examination of the three T-Tests in Table 28 indicated that significant differences were found between programs one and two and programs one and three, but not between programs two and three. These findings supported the results reported for $H_o$ I1. On the basis of these tests the null hypothesis was rejected.

Null Hypothesis I3 was tested by using a univariate 1-way analysis of variance to compare the group changes of category of clue choice and the size of the group. A summary of mean scores by group size is presented in Table 29. The results of the ANOVA analysis is presented in Table 30.

## TABLE 29

### SUMMARY OF MEAN CHANGES IN GROUP CHOICE OF CLUES BY GROUP SIZE AND POSITION IN PROGRAM SERIES

| Group Size | Program | | |
|---|---|---|---|
| | First | Second | Third |
| 1 | 11.5 | 5.3 | 8.3 |
| 2 | 16.6 | 10.5 | 5.3 |
| 3 | 12.3 | 9.7 | 6.0 |
| 5 | 11.8 | 7.0 | 4.17 |

## TABLE 30

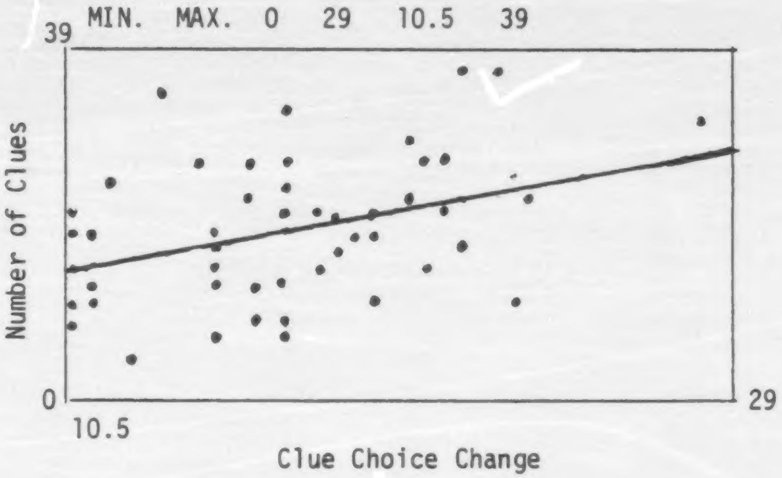
### UNIVARIATE ONE-WAY ANALYSIS OF VARIANCE OF GROUP SIZE AND NUMBER OF GROUP CATEGORY CHANGES IN CLUE CHOICE

| Group | N | Mean | Standard Deviation |
|---|---|---|---|
| 1 | 8 | 8.0 | 6.37 |
| 2 | 17 | 10.471 | 8.001 |
| 3 | 16 | 9.75 | 6.213 |
| 5 | 15 | 7.467 | 5.986 |

| Source | DF | Sum of Squares | Mean Squares | F Value | Significance |
|---|---|---|---|---|---|
| Between | 3 | 88.389 | 29.463 | .641 | .595 |
| Within | 52 | 2388.969 | 45.942 | | |
| Total | 55 | 2477.357 | | ETA-SQR = .036 | |

An examination of Table 29 indicated that the mean changes of categories declined consistently for teams of students, but increased in program three for individuals, pointing toward more erratic strategy. An examination of Table 30 indicated that there was no significant difference in the number of changes in clue choice within the four group sizes. Therefore on the basis of this test the null hypothesis was not rejected.

Null Hypothesis I4 was tested using a correlation R-Plot to determine the relationship of time to solution to the number of category changes in clue choice. The result of this analysis is presented in Figure 20.



r = .432 y = .432 x X = 20.238

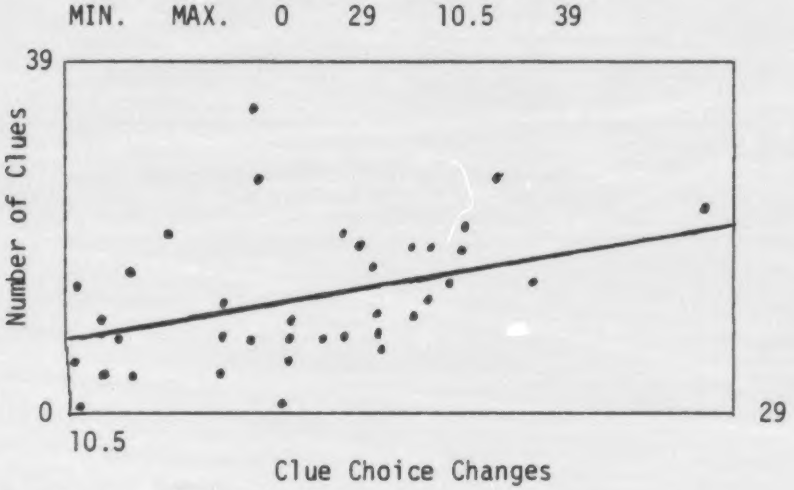
Mean X = 8.982
Mean Y = 24.12
S.D. X = 6.684
S.D. Y = 6.687

Sig. @ .05 = .261

Figure 20. R-Plot of Number of Group Change of Category of Clue Choice With Time to Solution, N = 56

An examination of the results in Figure 20 indicated a correlation of .432 between the number of clue choice changes and time needed to solve the problem. This r of .432 was significant at the .05 and the .01 levels, therefore on the basis of this test of correlation, the null hypothesis was rejected.

Null Hypothesis I5 was tested using a correlation R-Plot to determine the relationship of clues needed to solution and the number of category changes of clue choice. The results of this analysis are presented in Figure 21.



r = .444 y = .749 x X + 21.29

Mean X = 9.107
Mean Y = 28.107
S.D. X = 6.711
S.D. Y = 11.313

Sig. @ .05 = .261

Figure 21. R-Plot of Number of Group Changes of Category of Clue Choices With Number of Clues Required for Solution, N=56

An examination of the results in Figure 21 indicated a correlation of .444 between the number of clue choice changes and the number of clues needed to solve the program. This r of .444 was significant at both the .05 and .01 levels, therefore on the basis of this test of correlation the null hypothesis was rejected.

Null Hypothesis I was generated to investigate a question of true interest that emerged in this study. It was tested using five study variables which have already been explored in other ways in other analyses. In four of these five tests, the null hypothesis of no significance was rejected. Only the group size relationship was not significant even though teams of subjects seemed to show more consistency. These results provided enough evidence to suggest that such an exploration of the strategy of category change would be a viable and valuable study topic.

## Canonical Variate Analysis

It seemed imperative in an exploratory study such as this to include a rigorous search for possible previously undisclosed interactions or to ascertain that all important interactions have been analyzed. This was accomplished by utilizing the canonical variate analysis. Hotelling's canonical variate analysis (CVA) is a statistical method for studying relations between two sets of variables, when each set contains more than one variable (Amick and Walberg, 1975). In this search for interactions, ten independent variables composed one set and nine dependent variables composed the other set.

A null hypothesis was developed for this analysis in an effort to substantiate statistical and descriptive results already presented and discussed as well as to search out the unexpected.

> Null Hypothesis J: There is no significant degree of relationship between the dependent and independent variables.

The matrix of coefficients for canonical variables is presented in Table 31.

## TABLE 31

## CANONICAL VARIATE ANALYSIS OF THE RELATIONSHIPS BETWEEN TEN INDEPENDENT AND NINE DEPENDENT STUDY VARIABLES

| Tests of Independence | Statistic | DF | Significance |
|---|---|---|---|
| Likelihood Ratio | 151.08 | 90 | .0001 |
| Largest Root | 0.6237 | 0., 22.5 | -0. |

Coefficients for Canonical Variables N = 66 out of 66

| Variable | (1) | (2) | (3) | (4) | (5) |
|---|---|---|---|---|---|
| Correlation | 0.7897 | 0.7567 | 0.5645 | 0.4793 | 0.3965 |
| 1. Sex | 0.15745 | 0.13212 | -0.23464 | -0.15807 | 0.30532 |
| 2. Age | 0.07386 | -0.15215 | 0.02431 | -0.34009 | -0.98589 |
| 3. Grade | 0.20612 | 0.35634 | -0.75309 | -0.21052 | -0.45617 |
| 4. Grade Average | 0.30296 | -0.13199 | -0.68425 | -0.48931 | -0.18464 |
| 5. Computer Exp. | -0.20475 | -0.08913 | -0.50408 | -0.18434 | -0.24043 |
| 6. Group Size | -0.60821 | -0.52735 | -0.45023 | -0.16822 | -0.31121 |
| 7. Matrix Tr. | -0.16491 | 0.39225 | -0.06765 | 0.82651 | 0.05638 |
| 8. Day Freq. | -0.37747 | 0.38849 | -0.37985 | -0.17663 | 0.74290 |
| 9. V.R. Test* | 0.38927 | -0.11066 | -0.07429 | 0.68691 | 0.47503 |
| 10. C.S. Test* | 0.01316 | -0.15453 | 0.05805 | -0.07486 | 0.14595 |
| 11. Wrote | 0.25021 | -0.17246 | 0.16198 | 0.29061 | 0.23616 |
| 12. Use Matrix | 0.17214 | -0.02908 | -0.58055 | -0.68697 | 0.39276 |
| 13. Prog. Solved | -0.02943 | -0.12967 | -0.08707 | -0.27901 | -0.76633 |
| 14. Time 1* | -0.14550 | 0.03545 | 1.0203 | 0.70483 | -0.55603 |
| 15. Time 2 | 0.12973 | 1.0363 | -0.60654 | -0.82501 | -0.18264 |
| 16. Time 3 | 0.08999 | 0.20184 | -0.52317 | -0.12692 | -0.33964 |
| 17. Clue 1 | -0.16854 | 0.01310 | -0.92324 | 0.33739 | 0.42142 |
| 18. Clue 2 | -1.1280 | -0.92615 | 0.74865 | -0.11121 | 0.51006 |
| 19. Clue 3 | 1.0742 | 0.54352 | 0.60425 | -0.20739 | -0.07009 |

*V.R. Test = Verbal Reasoning Test *C.S. Test = Cognitive Survey
*Time 1 = Time in Program One

An examination of Table 31 indicated that in the tests for independence, the likelihood of a null hypothesis of no relationship between the two sets of variables was rejected at a significance level of .0001. The first five correlation coefficients ranged from .7897 to .3965. No correlation was considered in this search for influential factors if the r was less than half the value of the largest correlation in the set.

The first pair of canonical variates (r = .7897) seemed to identify a tendency for subjects who were in a smaller group size with a higher verbal reasoning test and working on sequential days to use fewer clues in program two and more clues in program three.

The second pair of canonical variates (r = .7567) seemed to identify eighth grade subjects in a smaller group size who have not had matrix training and who are in a once-a-week sequence of programs to take considerably more time and fewer clues in program two.

The third pair of canonical variates (r = .5654) seemed to identify younger subjects in a smaller group with a lower grade average and no computer experience to require more time and fewer clues in program one.

The fourth pair of canonical variates (r = .4793) seemed to identify subjects with no matrix training who have a low grade average and a high verbal reasoning score to not use the matrix strategy and to require more time in program one and less time in program two.

The fifth pair of canonical variates (r = .3965) seemed to identify a tendency for younger students with a high verbal reasoning test score working once-a-week to solve less programs, take less time and more clues in program one, more clues in program two and not use a matrix strategy.

In this canonical correlation matrix there were three independent variables and two dependent variables which did not have high correlation value and were not a major factor in any of the five interpretations. Those five (sex, age, cognitive survey score, writing, and time in program three) were deleted from the variable list and another canonical variate analysis was run to look for possibly stronger relationships. The results of the second analysis are presented in Table 32.

An examination of Table 32 indicated that in the test of independence the likelihood ratio was slightly lower but still significant. Canonical variate correlations ranged from .7716 to .4494 in four steps.

The first pair of canonical variates (r = .7716) seemed to identify a tendency for subjects in a smaller group with a higher verbal reasoning test score who worked in daily sessions to require a fewer number of clues in program two and a greater number of clues in program three.

The second pair of canonical variates (r = .7250) seemed to identify a tendency for subjects with a higher grade average and no matrix training in a larger group size that worked in daily sessions to require less time and more clues in program two and fewer clues in program three.

## TABLE 32

## CANONICAL VARIATE ANALYSIS OF THE RELATIONSHIPS BETWEEN SEVEN INDEPENDENT AND SEVEN DEPENDENT STUDY VARIABLES

| Tests of Independence | Statistic | DF | Significance |
|---|---|---|---|
| Likelihood Ratio | 133.95 | 49 | .0000 |
| Largest Root | 0.5954 | -.5, 25.0 | .0000 |

Coefficients for Canonical Variables N = 66 out of 66

| Variable | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| Correlation | 0.7716 | 0.7250 | 0.5165 | 0.4494 |
| 3. Grade | 0.24655 | -0.06591 | 0.55410 | 0.50042 |
| 4. Grade Average | 0.29359 | 0.32400 | 0.51014 | 0.60892 |
| 5. Computer Exper. | -0.21505 | 0.22249 | 0.31920 | 0.18224 |
| 6. Group Size | -0.64913 | 0.52133 | 0.30751 | 0.19366 |
| 7. Matrix Training | -0.16881 | -0.45603 | 0.38093 | -0.78852 |
| 8. Day Frequency | -0.36344 | -0.35701 | 0.46896 | 0.36891 |
| 9. V.R. Test* | 0.35190 | 0.13089 | 0.25778 | -0.59592 |
| 12. Use Matrix | 0.20851 | 0.19523 | 0.35024 | 0.72769 |
| 13. Prog. Solved | 0.00677 | 0.14753 | -0.01460 | 0.19185 |
| 14. Time Prog. 1 | 0.07795 | -0.19537 | -0.66357 | -1.1100 |
| 15. Time Prog. 2 | 0.18625 | -0.93014 | 0.68810 | 1.1331 |
| 17. Clue Prog. 1 | -0.28560 | 0.14035 | 0.80316 | -0.09986 |
| 18. Clue Prog. 2 | -1.2536 | 0.61140 | -0.71117 | 0.10269 |
| 19. Clue Prog. 3 | 1.1974 | -0.55715 | -0.41734 | 0.08487 |

*V.R. Test = Verbal Reasoning Test

The third pair of canonical variates (r = .5165) seemed to identify a tendency for eighth grade subjects with a higher grade average working in once-a-week sessions to take less time and more clues in program one and more time and fewer clues in program two.

The fourth pair of canonical variates (r = .4494) seemed to identify a tendency for eighth grade subjects with a higher verbal reasoning test score and no matrix training to be likely to use a matrix and require less time in program one and more time in program two.

The canonical correlation variate analyses indicated that strong, significant correlations did exist between most of the independent and dependent variables. Many of these highly correlated relationships have been analyzed and discussed in either the descriptive analyses in Chapter III or the study hypotheses in this chapter. In the search for study interactions which may have eluded the author, no unusual or outstanding relationships were uncovered. There were no surprises. On the basis of these test results the null hypothesis of no significant relationships must be rejected.

## A Final Test of Relationships: Multiple Regression Analyses

As a culminating test of relationships, the multiple regression analyses was used to test the major problems of this study to measure the degree to which the major covariates and treatment influence the observations. The analysis was extended to include other independent variables characterizing students (sex, age, grade, grade average, and verbal reasoning test scores) and an observation not included in the original research design: the number of clues required. The results of these analyses are presented in a statistical table of major covariates and treatment in Table 33, a table of more restricted data in Table 34, other independent variables in Table 35, and a summary table of significances for all the variables in Table 36. It should be noted that when analyzing achievement of time and clues needed, only those subjects who solved all programs were included since the desired predictors were for successful problem-solvers.

An examination of the regression analyses in Table 33 and the first portion of the summary in Table 36 indicated that all covariates influenced the study observations to some degree. The size of the group was the best predictor of achievement measured by time and clues needed. This relationship was inverse indicating that the smaller group (or the individual) required more time and clues, and larger groups required less time and clues to solution.

Program difficulty (random order) significantly and inversely influenced the first programs supporting the research hypothesis results that sequence E and F appeared to be easier. The frequency of session appeared to have a significant inverse influence over the last programs indicating that daily sessions required more time and clues, and once-a-week groups required less time and clues. The inverse relationship of day frequency to problems solved supported the results in research hypothesis G where daily groups solved more programs but not to a significant degree.

## TABLE 33

## STEPWISE REGRESSION ANALYSES OF MAJOR COVARIATE AND TREATMENT DATA ON THE STUDY OBSERVATIONS (SUMMARIES OF ANALYSES USING FORWARD SELECTION)

### Study Observation: Number of Programs Solved

N = 66

| Step | R-Square | Standard Error | Weight of Variable | Variable | | Partial | Sig. |
|---|---|---|---|---|---|---|---|
| 1 | 0.13505 | 0.73983 | 1 | Day Freq. | IN | -0.36750 | .0024 |
| | | | | Remaining | | | |
| | | | | Group Size | | 0.14469 | .2502 |
| | | | | Matrix Tr. | | -0.16577 | .1869 |
| | | | | Cog. Surv. Test | | 0.14891 | .2365 |
| | | | | Seq. Order | | 0.04430 | .7261 |

### Study Observation: Use of Matrix

N = 66

| Step | R-Square | Standard Error | Weight of Variable | Variable | | Partial | Sig. |
|---|---|---|---|---|---|---|---|
| 1 | 0.07465 | 0.91826 | 1 | Cog. S. Test | IN | 0.27322 | .0264 |
| | | | | Remaining | | | |
| | | | | Group Size | | -0.12429 | .3239 |
| | | | | Matrix Tr. | | -0.18591 | .1381 |
| | | | | Day Freq. | | -0.00820 | .9483 |
| | | | | Seq. Order | | -0.23332 | .0614 |

### Study Observation: Time in Program One

N = 43 (Solved Programs)

| Step | R-Square | Standard Error | Weight of Variable | Variable | | Partial | Sig. |
|---|---|---|---|---|---|---|---|
| 1 | 0.72877 | 4.3234 | 1 | Seq. Order | IN | -0.85368 | .0000 |
| 2 | 0.79967 | 3.7618 | 2 | Group Size | IN | -0.51126 | .0005 |
| 3 | 0.83208 | 3.4880 | 3 | Cog. S. Test | IN | -0.40223 | .0091 |
| | | | | Remaining: none | | | |

TABLE 33 (continued)

Study Observation: Time in Program Two

N = 43 (Solved Programs)

| Step | R-Square | Standard Error | Weight of Variable | Variable | | Partial | Sig. |
|---|---|---|---|---|---|---|---|
| 1 | 0.29742 | 4.5206 | 1 | Group Size | IN | -0.54536 | .0002 |
| 2 | 0.41763 | 4.1668 | 2 | Seq. Order | IN | -0.41364 | .0065 |
| 3 | 0.47926 | 3.9904 | 3 | Matrix Tr. | IN | 0.32530 | .0380 |
| | | | | Remaining | | | |
| | | | | Day Freq. | | 0.15525 | .3388 |
| | | | | Cog. S. Test | | -0.23723 | .1405 |

Study Observation: Time in Program Three

N = 43 (Solved Programs)

| Step | R-Square | Standard Error | Weight of Variable | Variable | | Partial | Sig. |
|---|---|---|---|---|---|---|---|
| 1 | 0.45443 | 3.3298 | 1 | Group Size | IN | -0.67411 | .0000 |
| 2 | 0.62062 | 2.8112 | 2 | Day Freq. | IN | -0.55193 | .0002 |
| 3 | 0.69052 | 2.5714 | 3 | Matrix Tr. | IN | 0.42922 | .0051 |
| | | | | Remaining | | | |
| | | | | Cog. S. Test | | 0.29805 | .0618 |
| | | | | Seq. Order | | -0.13438 | .4084 |

Study Observation: Clues in Program One

N = 43 (Solved Programs)

| Step | R-Square | Standard Error | Weight of Variable | Variable | | Parital | Sig. |
|---|---|---|---|---|---|---|---|
| 1 | 0.27636 | 10.166 | 1 | Seq. Order | IN | -0.52570 | .0003 |
| 2 | 0.38293 | 9.5039 | 2 | Group Size | IN | -0.38376 | .0121 |
| | | | | Remaining | | | |
| | | | | Cog. S. Test | | -0.30397 | .0533 |

TABLE 33 (continued)

Study Observation: Clues in Program Two

N = 43 (Solved Programs)

| Step | R-Square | Standard Error | Weight of Variable | Variable | | Partial | Sig. |
|---|---|---|---|---|---|---|---|
| 1 | 0.21488 | 6.6804 | 1 | Group Size | IN | -0.46355 | .0017 |
| 2 | 0.30034 | 6.3847 | 2 | Matrix Tr. | IN | 0.32993 | .0329 |
| | | | | Remaining | | | |
| | | | | Day Freq. | | -0.16669 | .2976 |
| | | | | Cog. S. Test | | 0.04181 | .7952 |
| | | | | Seq. Order | | -0.08831 | .5830 |

Study Observation: Clues in Program Three

N = 43 (Solved Programs)

| Step | R-Square | Standard Error | Weight of Variable | Variable | | Partial | Sig. |
|---|---|---|---|---|---|---|---|
| 1 | 0.40319 | 7.4827 | 1 | Group Size | IN | -0.63497 | .0000 |
| 2 | 0.45994 | 7.2065 | 2 | Day Freq. | IN | -0.30836 | .0469 |
| | | | | Remaining | | | |
| | | | | Matrix Tr. | | -0.11284 | .4824 |
| | | | | Cog. S. Test | | 0.04181 | .7952 |
| | | | | Seq. Order | | -0.02082 | .8972 |

## TABLE 34

## MULTIPLE LINEAR REGRESSION OF THE TREATMENT MATRIX TRAINING ON PROBLEM SOLVING AND MATRIX USE USING ONLY DATA AFTER THE MATRIX TRAINING (SECOND AND THIRD PROGRAMS)

Study Observation: Problem Solved

N = 66

| Study Treatment | Constant | Variable | R-Square | Coefficient Multiple Correlation | Standard Error | F Value |
|---|---|---|---|---|---|---|
| Matrix Tr. | 2.7878 | -0.09091 | 0.00650 | 0.806 | 0.57075 | 0.41860 |

Study Observation: Matrix Used

N = 66

| Study Treatment | Constant | Variable | R-Square | Coefficient Multiple Correlation | Standard Error | F Value |
|---|---|---|---|---|---|---|
| Matrix Tr. | 2.69697 | -0.3939 | 0.06059 | 0.24616 | 0.78757 | 4.1282 |

(Significance at .05 = 3.99)

## TABLE 35

## STEPWISE REGRESSION ANALYSES OF SEX, AGE, GRADE, GRADE AVERAGE, AND VERBAL REASONING TEST SCORE DATA ON THE STUDY OBSERVATIONS (SUMMARIES OF ANALYSES USING FORWARD SELECTION)

Study Observation: Number of Programs Solved

N = 66

| Step | R-Square | Standard Error | Weight of Variable | Variable | | Partial | Sig. |
|---|---|---|---|---|---|---|---|
| 1 | 0.08062 | 0.76275 | 1 | Grade Ave. | IN | 0.28394 | .0209 |
| | | | | Remaining | | | |
| | | | | Sex | | -0.8029 | .5249 |
| | | | | Age | | 0.05104 | .6864 |
| | | | | Grade | | -0.00221 | .9861 |
| | | | | V.R. Test | | -0.03009 | .8119 |

Study Observation: Use of Matrix

N = 66

| Step | R-Square | Standard Error | Weight of Variable | Variable | | Partial | Sig. |
|---|---|---|---|---|---|---|---|
| 1 | 0.13616 | 0.88722 | 1 | Grade Ave. | IN | 0.36900 | .0023 |
| | | | | Remaining | | | |
| | | | | Sex | | 0.06346 | .6155 |
| | | | | Age | | 0.10411 | .4092 |
| | | | | Grade | | 0.06512 | .6063 |
| | | | | V.R. Test | | 0.04672 | .7117 |

Study Observation: Time in Program One

N = 43 (Solved Programs)

| Step | R-Square | Standard Error | Weight of Variable | Variable | | Partial | Sig. |
|---|---|---|---|---|---|---|---|
| 1 | 0.11705 | 7.8006 | 1 | Grade Ave. | IN | -0.34212 | .0247 |
| | | | | Remaining | | | |
| | | | | Sex | | -0.14721 | .3522 |
| | | | | Age | | 0.17084 | .2794 |
| | | | | Grade | | 0.13735 | .3857 |
| | | | | V.R. Test | | -0.03428 | .8293 |

TABLE 35 (continued)

Study Observation: Time in Program Two

N = 43 (Solved Programs)

| Step | R-Square | Standard Error | Weight of Variable | Variable | | Partial | Sig. |
|---|---|---|---|---|---|---|---|
| 1 | 0.26394 | 5.2282 | 1 | V.R. Test | IN | -0.51375 | .0000 |
| | | | | Remaining | | | |
| | | | | Sex | | 0.02353 | .8524 |
| | | | | Age | | 0.10239 | .4170 |
| | | | | Grade | | 0.23189 | .0631 |
| | | | | Grade Ave. | | -0.24231 | .0518 |

Study Observation: Time in Program Three

N = 43 (Solved Programs)

| Step | R-Square | Standard Error | Weight of Variable | Variable | | Partial | Sig. |
|---|---|---|---|---|---|---|---|
| 1 | 0.53142 | 3.0859 | 1 | Grade | IN | 0.72898 | .0000 |
| | | | | Remaining | | | |
| | | | | Sex | | 0.02689 | .8658 |
| | | | | Age | | 0.02657 | .8674 |
| | | | | Grade Ave. | | 0.05835 | .7136 |
| | | | | V.R. Test | | -0.02216 | .8892 |

Study Observation: Clues in Program One

N = 43 (Solved Programs)

| Step | R-Square | Standard Error | Weight of Variable | Variable | | Partial | Sig. |
|---|---|---|---|---|---|---|---|
| 1 | 0.09093 | 11.394 | 1 | Age | IN | 0.30155 | .0494 |
| | | | | Remaining | | | |
| | | | | Sex | | 0.10420 | .5114 |
| | | | | Grade | | 0.09232 | .5609 |
| | | | | Grade Ave. | | -0.12485 | .4308 |
| | | | | V.R. Test | | 0.10369 | .5134 |

TABLE 35 (continued)

Study Observation: Clues in Program Two

N = 43 (Solved Programs)

| Step | R-Square | Standard Error | Weight of Variable | Variable | | Partial | Sig. |
|---|---|---|---|---|---|---|---|
| 1 | 0.28458 | 6.3770 | 1 | V.R. Test | IN | -0.53346 | .0002 |
| 2 | 0.36971 | 6.0599 | 2 | Grade | IN | 0.34495 | .0253 |
| | | | | Remaining | | | |
| | | | | Sex | | 0.16960 | .2891 |
| | | | | Age | | 0.17438 | .2755 |
| | | | | Grade Ave. | | -0.11981 | .4556 |

Study Observation: Clues in Program Three

N = 43 (Solved Programs)

| Step | R-Square | Standard Error | Weight of Variable | Variable | | Partial | Sig. |
|---|---|---|---|---|---|---|---|
| 1 | 0.24557 | 8.4130 | 1 | Age | IN | 0.49555 | .0007 |
| 2 | 0.39082 | 7.6538 | 2 | Sex | IN | 0.43878 | .0037 |
| | | | | Remaining | | | |
| | | | | Grade | | 0.26441 | .0948 |
| | | | | Grade Ave. | | -0.03325 | .8365 |
| | | | | V.R. Test | | -0.00554 | .9726 |

## TABLE 36

## SUMMARY OF SIGNIFICANT INFLUENCES OF INDEPENDENT VARIABLES ON THE OBSERVATIONS USING THE STEPWISE REGRESSION ANALYSES

| Variables | Observations | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Major Covariates | Programs Solved | Use of Matrix | Time to Solution | | | Clues to Solution | | |
| | | | P.1 | P.2 | P.3 | P.1 | P.2 | P.3 |
| Cognitive Survey Test Scores | -- | Sig. | Sig. | - | - | - | - | - |
| Program Cell Size | Analyzed within covariate "Random Order" | | | | | | | |
| Random Order of Programs | - | - | Sig. | Sig. | - | Sig. | - | - |
| Size of Group | - | - | Sig. | Sig. | Sig. | Sig. | Sig. | Sig. |
| Day Frequency | Sig. | - | N.A. | - | Sig. | N.A. | - | Sig. |
| Treatment | | | | | | | | |
| Matrix Training | - | (Sig.) | N.A. | Sig. | Sig. | N.A. | Sig. | - |
| Other Independent Variables | | | | | | | | |
| Sex | - | - | - | - | - | - | - | Sig. |
| Age | - | - | - | - | - | Sig. | - | Sig. |
| Grade | - | - | - | - | Sig. | - | Sig. | - |
| Grade Average | Sig. | Sig. | Sig. | - | - | - | - | - |
| Verbal Reasoning Test Score | - | - | - | Sig. | - | - | Sig. | - |

P = Program
Sig. = Significant at the .05 level
( ) = Test conducted using data _after_ matrix training
N.A. = Not applicable

Results also indicated that the cognitive survey test score had inverse influence on the time in the first program but not in the succeeding ones. This test score also had direct influence on the use of a matrix; the higher the cognitive test score, the more likley that a matrix strategy will be used.

The study treatment, matrix training, presented a special problem since the training was only given after the first session and cannot have any influence on any data from session one. Data restricted to sessions two and three were retrieved and analyzed on a microcomputer statistical program of multiple linear regression to determine more accurate relationships of matrix training to the study observations. These results are presented in Table 34 and in parentheses in the summary in Table 36. The results indicated that matrix training did have a significant influence on the use of a matrix strategy, supporting the results of Hypothesis B. Matrix training also had significant influence on time needed in both programs two and three; those with matrix training required less time.

An examination of Table 35 indicated that there are significant relationships among the other independent variables. Results indicated that younger students with a higher grade average and a higher verbal reasoning test score require less time and use less clues.

When compared with the null hypotheses analyses and the canonical variate analyses, the results of the multiple regression analyses displayed many similarities and supported significant relationships.

## Summary

This research could be classified as a quasi correlational design. Initial observations were organized into a variety of parametric and non-parametric tables and graphs. Null hypotheses were developed for the seven research hypotheses, tested and examined for significant differences. Null hypotheses were also developed for two questions of true interest; an analysis of clue choice and an in-depth search for further interactions. These new hypotheses were tested and examined for significance. The multiple regression analysis, using the stepwise method of forward selection, was used as a culminating test of relationships to measure the degree to which the covariates, treatment, and other independent variables influenced the observations.

The major findings of these analyses are:

1. Subjects improved their skill by decreasing the time required for solution in successive programs. More change was noted between programs one and two and programs one and three than between the second and third programs. This was attributed to an initial search for a strategy in program one, finding a satisfactory strategy in program two and improving it in program three.

2. Subjects who participate in a matrix training session will be more likely to use a matrix strategy to solve similar problems. Reinforcement of a matrix strategy at the end of each program appeared to influence daily sessions more than

the once-a-week participants.

3. Groups using the matrix strategy throughout all sessions did not require significantly less time to solve the programs. In an analysis by separate session, there was some evidence that the matrix users needed significantly less time in the third session.

4. There were significant differences in the number of subjects on a team and the time required to reach a solution. This relationship appeared to be curvilinear. Individuals working alone were not consistent in improvement in time needed. Teams of five showed the best times.

5. There was a curvilinear relationship between group size and achieving a correct solution. Individuals solved significantly fewer programs than teams, and teams of two or three tended to solve more problems with greater consistency than larger teams of five.

6. Within the six sequence series of programs there were some significant differences in individual programs solved and time and clues required. However, there were inconsistencies that leave the conclusions in doubt. Results suggested that the least difficult sequence may be (in order): "Global Travelers," "Vertebrate Pets," and "Energy at Home."

7. Subjects who were involved in daily sessions solved more programs but not significantly more than the once-a-week subjects. Daily workers consistently took less time than once-a-week subjects but the difference was not significant.

8. The frequency of category changes in choice of clues declined consistently from the first to the third program sessions. The more the category changes of clues, the more time and clues were needed to correctly solve the research program. There was no significant relationship between group size and frequency of category change.

9. Two canonical variate analyses of ten independent variables with nine dependent variables indicated a highly significant likelihood of relationship between the variables. Strong, significant correlations did exist but no new or unusual interactions were discovered.

10. In an overall summary, multiple regression analyses supported the findings for both the null hypotheses and the canonical variate analyses. Significant results indicated that the size of the group had the most influence in overall problem-solving achievement; individuals took longer and required more clues, and teams required less time and clues. Once-a-week subjects solved fewer problems with a better time and fewer clues in the last program, and

those who had matrix training used the matrix strategy more and took less time and clues to solve the problem. The higher the grade average the more problems that were solved using a matrix strategy, and the younger subjects appeared to require less time and clues. Sex differences had significant influence in clues needed in program three where males required fewer clues. In program two, the higher the verbal reasoning test score the less time and fewer clues that were required.

# CHAPTER V

# SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

## Summary

### Purpose

Since the acquisition of problem-solving skills is considered an important component of the development of a scientifically, technologically and environmentally literate citizen, the utilization of all available methods and materials should be considered including the newest in technological aids. The purpose of this thesis was to study early adolescent use of selected problem-solving skills using microcomputers. The study examined two major areas:

1. Evaluating the characteristics, interactions, skill strategies and achievement of junior high school students as they interacted with a microcomputer in three problem-solving sessions, and
2. Determining the effectiveness of three newly developed and adapted microcomputer programs in problem-solving, and a fourth program in specific skill training in organizing data.

### Procedure

Three programs of logic and reasoning requiring problem-solving skills, and an interactive training program in the organization of data were developed for a Commodore PET microcomputer. A cognitive test surveying prior knowledge of program content was developed.

Seventh and eighth grade student subjects were recruited from study hall classes in four junior high schools in two suburban school districts, Farmington and Clarenceville, in metropolitan Detroit. All volunteers were accepted: 55 subjects from study hall classes, six from a gifted program, and five from academic classes.

After responding to the Cognitive Inventory Survey, an identification number was assigned and subjects randomly assigned, within time restrictions, to individual sessions or to teams of two, three or five. Within a normal class period of 50 minutes, half the subjects worked on consecutive days, the other half met once a week. Half the subjects received a special training session on organizing data at the beginning of the second session, half received no special session. Sixty-six of the volunteers completed the series of three interactive problem-solving tasks. Five groups representing twenty-one subjects were dropped from the research sample because of absenteeism.

Data on subject characteristics, time and clues needed for solution and order of clues were saved internally by the microcomputer for later retrieval. Interaction observations of subject with subject, and subject with microcomputer were recorded. Program difficulty, interactions, skill strategies and achievement over the three program sessions were analyzed.

## Hypotheses

Research and null hypotheses were developed for this study and results are summarized below.

> Research Hypothesis A: There are unique motivational and interactive trends and patterns that occur when adolescents interact with a microcomputer.

Research Hypothesis A was supported by anecdotal observation analysis. The results of the subjective evaluation of observations indicated that:

1. Subjects appeared to adapt very quickly and easily to the mechanics of the microcomputer.

2. Subject interest remained consistently high throughout all sessions. There were no withdrawals.

3. Most subjects did not change the standardized seating arrangements although they were free to do so. Those who did change the seating also exhibited tension, discordance, and lack of team effort within the group.

4. All subjects indicated that they were unfamiliar with this particular style of complex problem. First sessions involved "trial and error" methods. Second and third programs were attacked with increased confidence and improved strategies. Some subjects persisted in the original strategy, others were more open to change.

5. Most individuals within groups insisted on everyone taking turns. In those groups where turns were not taken in a somewhat organized fashion, friction within the group usually resulted. In most groups everyone took part in the deliberations to some degree.

6. Subjects who were within one grade average level worked

together as a team. Subjects who were two or more grade average levels apart had difficulty working together and did not seem to understand the strategy employed by the others. The "D" grade-average subjects were erratic, impatient, impulsive and demanded attention, approval and encouragement from the adult present.

> Null Hypothesis B: As each successive program is played, there is no significant difference in the time required to reach a correct solution. (Research Hypothesis: Students will improve their skill by decreasing the time required for correct solution.)
>
> > Sub $H_0$B1: There is no significant difference in the time required to reach a correct solution from program one to program two. Rejected.
> >
> > Sub $H_0$B2: There is no significant difference in the time required to reach a correct solution from program two to program three. Not rejected.
> >
> > Sub $H_0$B3: There is no significant difference in the time required to reach a correct solution from program one to program three. Rejected.

Null Hypothesis B was rejected and the research hypothesis was supported. The results of the pairwise T-tests by student times indicated highly signficant differences exist between all pairs of programs: from program one to program two, p = .0003; from program two to program three, p = .0088; from program one to program three, p = .0000. The results of the more rigorous matched T-tests by group time indicated signifcant differences between programs one and two (t = 2.281 where p @ .05 = 2.160) and programs one and three (t = 2.597 where p @ .05 = 2.160) but no signficant difference between the mean times in programs two and three (t = 1.157 where p @ .05 = 2.160). The matched analysis of variance by group time indicated signficant differences between programs (F = 2.98 where p @ .05 = 2.125) and within programs (F = 5.03 where p @ .05 = 3.37).

> Null Hypothesis C: There is no significant difference in the use of a matrix strategy between the subjects who participate in an interactive matrix training session and those who do not. (Research Hypothesis: Subjects with training will use the matrix strategy more.)

Null Hypothesis C was rejected and the research hypothesis was supported. The results of the Chi Square test for differences indicated highly significant differences when considering data from all papers in all programs (p = .0000008). The results of the Chi Square test when considering only data in the second and third programs after matrix training had taken place indicated less significant differences (p = .001). When the data were divided into daily sessions and once-a-week sessions, the results of the Chi Square test indicated no significant differences in daily sessions (p = .214) but highly significant differences in the once-a-week sessions (p = .0000005).

> Null Hypothesis D: There is no significant difference in the time needed for a correct solution between the groups in which at least one student used the matrix strategy and those groups in which no student used the matrix strategy when computed by position in the three program sequence. (Research Hypothesis: Groups using the matrix strategy will require less time.)

Null Hypothesis D was not rejected and the research hypothesis was rejected. The results of the point biserial correlation analysis indicated a correlation of -.2205 (p = .25). The results of a further point biserial analysis by position of the program in the three program sequence indicated significant differences only in the third program ($r_{pb}$ = -.4894 where p @ .05 = .433).

> Null Hypothesis E: There is no significant difference between the number of subjects on a team and the time required to reach a correct solution. (Research Hypothesis: There is a curvilinear relationship between group size and time to solution.)

Null Hypothesis E was rejected and the research hypothesis was supported. The results of the pairwise multiple comparisons indicated no significant difference between groups in program one (p = .1578), but highly significant differences in program two (p = .0004) and program three (p = .0000). Using the more rigorous Scheffe allowances, groups of five indicated highly significant differences when compared with groups of two (p = .0007) and groups of three (p = .0001) in program two. In program three results were again highly significant for groups of five when compared with groups of two (p = .0000) and groups of three (p = .0002). The results of an Nth correlation analysis supported the ANOVA pairwise comparison results. A line graph of Nth order regression fit for the three programs indicated a curvilinear pattern of relationships within group size supporting the research hypothesis.

> Null Hypothesis F: There is no significant difference in the number of subjects in a group and the achievement of a correct solution as measured by the number of programs solved. (Research Hypothesis: There is a curvilinear relationship between group size and achieving a correct solution.)

Null Hypothesis F was rejected and the research hypothesis was supported. The results of an analysis of variance indicated highly significant differences between the group sizes (p = .0005). The pairwise multiple comparisons indicated highly significant differences between the ones (individuals) and the groups of two (p = .0001), the threes (p = .0002), and the fives (p = .0004). A bar graph of frequency of problems solved by group size clearly indicated a curvilinear relationship supporting the research hypothesis.

> Null Hypothesis G: There is no significant difference in the order of difficulty of the three microcomputer programs when presented in random order. (Research Hypothesis: The three programs are of approximately equal difficulty.)
>
> > Sub $H_0$G1: There is no significant difference when measured by the number of programs solved. Rejected.
> >
> > Sub $H_0$G2: There is no significant difference when measured by time to solution. Rejected.
> >
> > Sub $H_0$G3: There is no significant difference when measured by the number of clues required for solution. Rejected.

Null Hypothesis G was rejected and the research hypothesis was also rejected. The results of the analysis of variance for $H_0$G1 indicated that there were significant differences in the number of problems solved within the six sequence orders of programs (p = .0002). The pairwise multiple comparison using the Scheffe allowances indicated that sequence D (programs: "Vertebrate Pets", "Global Travelers", "Energy At Home") had significantly fewer programs solved than sequences A (p = .0003), C (p = .0000), E (p = .0003) and F (p = .0001). Bar graphs of frequencies of solved programs indicated that the program "Vertebrate Pets" had the fewest solved programs, "Energy At Home" was solved more often, and that all programs varied according to their position in the sequence.

The results of the analysis of variance for $H_0$G2 indicated that there were significant differences in times to solution within the six sequence orders of programs in the first session (p = .0000), the second session ($p = .0002$), and the third session ($p = .0383$). The pairwise multiple comparisons using the Scheffe allowances indicated that in the first session "Global Travelers" required significantly less time than sequences A ($p = .0000$), B ($p = .0000$), C ($p = .0001$) and D ($p = .0000$). In the second session "Vertebrate Pets" required significantly less time than "Global Travelers" ($p = .0000$), as did "Energy At Home" when compared to "Global Travelers" ($p = .0002$). Session three had no significant differences within the six sequences.

The results of the analysis of variance for $H_0G3$ indicated that there were significant differences in clues needed for solution within the six sequence orders ($p = .0000$). The pairwise multiple comparisons using the Scheffe allowances indicated that significant differences were found only in the first session where "Global Travelers" required significantly less clues than programs in sequences A ($p = .0000$), C ($p = .0000$), and E ($p = .0001$). By combining these results it would appear that sequence F (1st, "Global Travelers"; 2nd, "Vertebrate Pets"; 3rd, "Energy At Home") was the least difficult.

> Null Hypothesis H: There is no significant difference between the achievement of groups who attempt to solve problems on three consecutive days and those groups who attempt to solve problems on a once-a-week basis. (Research Hypothesis: Daily problem solvers will show greater achievement.)
>
> Sub $H_0H1$: There is no significant difference when measured by number of programs solved. Not rejected.
>
> Sub $H_0H2$: There is no significant difference when measured by the time needed for solution. Not rejected.

Null Hypothesis H was not rejected and the research hypothesis was not supported. The results of the Chi Square test indicated no significant differences in problems solved ($x^2$ = .457 where p @ .05 = .796). The results of the Kolmogorov-Smirnov 2-sample test also indicated no significant differences (p = 1.7968). The results of three T-tests by group of average time to solution indicated no significant differences in the first program (p = .53), second program (p = .19), or the third program (p = .65).

> Null Hypothesis I: There are no significant differences in the number of category changes in clue choices as measured by:
>
> (1) the position of any solved problem,
> (2) successive programs solved,
> (3) group size,
> (4) time to solution, and
> (5) number of clues needed for solution.

Null Hypothesis I was rejected. This hypothesis was not in the original research design but emerged in a question of true interest. Results of the T-tests comparing the positions of any solved program indicated that significant differences were found between the first and second programs (p = .028) and the first and third programs (p = .008) but not significant between the second and third programs (p = .099). Results of the matched analysis of variance comparing category changes with successive programs solved ($H_0$I2) indicated significant differences between rows (F = 2.957 where p @ .05 = 2.125) and between groups (F = 10.205 where p @ .05 = 3.37). The results of matched T-tests of mean scores between successive programs indicated significant differences between the first and second programs (t = 3.139 where p @ .05 = 2.160) and the first and third programs (t = 3.4906 where p @ .05 = 2.160). Results of the analysis of variance for $H_0I3$ indicated that there were no significant differences between the size of the group and the number of category changes they made (p = .595). The results of the correlation R-plot to analyze the relationship of time to solution and the number of category changes of clues indicated a correlation of .432 which is significant at the .05 level. The results of the correlation R-plot to test $H_0I5$ indicated a significant correlation of .444.

> Null Hypothesis J: There is no significant degree of relationship between the dependent and independent variables.

Null Hypothesis J was rejected. This hypothesis is the second hypothesis to emerge from a question of true interest. The results of the first canonical variate analysis indicated that in the test of independence, the likelihood ratio was significant at .0001 with a statistic of 151.08. Variate correlations ranged from .7897 to .3965 in four steps. A second canonical variate analysis was completed with five variables deleted. The results indicated that the likelihood ratio was 133.95 which was significant at .0000. The variate correlations ranged from .7716 to .4494 in four steps.

## A Final Test of Relationships: Multiple Regression Analysis

As a culminating test of relationships, the multiple regression analysis was used to test the major problems of this study to measure the degree to which the major covariates and treatment influence the observations. The analysis was extended to include other independent variables characterizing students and an observation not included in the original research design; the number of clues required. Results supported the significant findings of both the null hypothesis and the canonical variate analyses. The results of the stepwise regression analysis indicated that the frequency of session (p = .0024) and grade average (p = .0209) were significant predictors of the number of problems solved. The Cognitive Inventory survey (p = .0264), grade average (p = .0023), and matrix training (F = 4.1282 where p @ .05 = 3.99) were significant predictors of the use of the matrix. Sequence order (p = .0000), group size (p = .0005), Cognitive Inventory survey (p = .0091), and grade average were significant predictors of the time to solution in the first program. Group size (p = .0002), sequence order (p = .0065), matrix training (p = .0380), and grade average (p = .0247) were significant predictors of time to solution in the second program. Group size (p = .0000), the frequency of session (p = .0002), matrix training (p = .0051), and grade (p = .0000) were significant predictors of time to solution in the third program. Sequence order (p = .0003), group size (p = .0121), and age of subject (p = .0494) were significant predictors of the number of clues needed for solution in the first program. Group size (p = .0017), matrix training (p = .0329), verbal reasoning test score (p = .0002), and grade (p = .0253) were significant predictors for clues needed for solution in the second program. Group size (p = .0000), frequency of session (p = .0469), age (p = .0007), and sex (p = .0037) were significant predictors of clues needed for solution in the third program.

## Conclusions

The following conclusions were drawn from this study:

1. There were unique patterns and trends when early adolescents interacted with a microcomputer to solve complex problems. Technical aspects of operating a microcomputer were minimal since all subjects adapted easily and quickly to its use. Subject interest remained high during all sessions regardless of achievement or variances of individual characteristics indicating a high motivational trend. Confidence in the ability to solve problems increased with each session indicating the usefulness of this research strategy with a microcomputer in the development of problem-solving skills.

2. Selected problem-solving skills were improved during the three research sessions indicating that students can improve in problem-solving skills in a very short time on a microcomputer.

3. The training session in organizing data into a matrix was successful in introducing a useable new strategy. Subjects with training used the strategy more although the time and clues needed were not significnatly affected, therefore, training on a microcomputer can be useful in developing skills.

4. Individuals worked better in teams than alone. Teams of two and three solved more problems indicating a curvilinear relationship between the groups of one, two, three and five. The teams of five solved problems in significantly less time and clues but social confrontations and friction occurred more often. Therefore, the

optimal sized working group would seem to be more than one and less than five.

5. While the three original microcomputer programs showed some significant differences there were some discrepancies in those differences. The sequence that appeared the easiest was (1) "Global Travelers," (2) "Vertebrate Pets," and (3) "Energy at Home." Observations indicated that the three programs were comparable in complexity, readability, and in holding the interest of the subjects.

6. While there were no statistically significant differences in achievement between daily sessions and once-a-week sessions, the once-a-week groups with training used more matrix strategies. Observations indicated that subjects were just as motivated when sessions were more infrequent.

7. There was an inverse relationship between problem-solving achievement and the number of times the subjects changed the category of their clue choice. This would indicate that the more the changes, the less apparent a workable strategy, the fewer the problems that were solved, and the more time and clues that were needed. Fewer category changes, therefore, were a good indicator of problem-solving skill.

8. Student academic abilities significantly influenced how many problems were solved and whether the matrix strategy was used, but the lack of significance in the time and clues needed indicate an influence of group synergy in problem-solving that enables the less academically endowed to participate and achieve in successful

problem-solving activities. All groups and individuals regardless of their tested or academic abilities were able to solve at least part of the research problems.

## Discussion

The conclusions drawn above indicated that the microcomputer had a high motivational influence on the research sessions. One of the consistently recurring criticisms of the mushrooming popularity of the microcomputer has been that "it's just another fad that will die away like so many other curriculum innovations" (Billings, 1980). However, few curriculum innovations have included a tool with such a wide diversity of applications across the disciplines and a potential for creative exploration by both the teacher and the student. Five years of existence is too short a time to adequately evaluate the educational value of any tool but the popularity, versatility, and positive student reactions cannot be denied.

The conclusions also indicated that this study successfully proved that selected problem-solving skills can be practiced, improved, and evaluated on a microcomputer. The three programs used were adaptations of a paper and pencil activity. It could be argued that the microcomputer was an unnecessary frill. That might be true if all that was desired was a right answer. If the positive values of shared strategy development are a desired objective, then an interactive program on a microcomputer adds a new and valuable dimension.

The training program in organizing data could not have been done by paper and pencil methods. It could conceivably be simulated by an instructor using a blackboard and cue cards. The microcomputer not only conducted a more efficient presentation but could free the instructor to act as a facilitator for several microcomputer groups or a class and a microcomputer.

## Recommendations

This research study has shown that microcomputers can be considered a viable, motivating aid for the development of problem-solving skills. In the research process many aspects of the interactions of early adolescents with microcomputer programs were explored and the results of analyses have implications and suggest recommendations for educational study and use.

1. The microcomputer programs were a key factor in the success of the study's skill-building effort. While these programs were successful, perhaps others could be more successful. Consideration should be given to a study of a variety of types of problem-solving situations such as simulations, logical problems, and games. High on the priority list should be a search for proven strategies which can be adapted to a microcomputer by a skilled programmer, since that is the way these research programs originated.

2. The training session in organizing data into a matrix proved to be useful to a significant number of students. However some subjects were satisfied with the strategy that had proven successful for them in earlier sessions. There are many ways to solve a problem and learning styles should be considered when developing and using

training strategies. Consideration should be given to further study on how data is put together to form alternative solutions. The training session in this study proved to be successful on a very short term of three sessions. This raises several questions. Will this strategy be retained for future use by the subject? Will this strategy be applied to other discipline areas and/or personal and community action problem-solving? Will this strategy be transmitted to others in team effort?

3. The subjects in this study represented a full range of abilities and achievements, all of whom were successful to a degree. Varying levels of problem-solving situations should be made available to any subject who wishes to participate and not be limited to or prioritized for the gifted program. Consideration should be given to a study of the relative achievement and motivation of all ability levels with both paper and pencil problems and the microcomputer version of an identical problem.

4. More males than females volunteered for the microcomputer sessions. Could this be a sexist reaction to the intricacies of technological apparatus? Observations in this study indicated that females contributed on a par with males but no statistical evidence supports this conclusion since most of the groups were mixed teams and existing data are not useful for such an analysis. Consideration should be given to a study of attitudes of the general population of students toward computers.

5. Teams of subjects were formed randomly for the research sessions and friction resulted in some cases. What would be the result if subjects could choose their own partners and size of group? Would they choose to work alone? or with the suggested optimal size of two or three? Consideration should be given to a study of the differences in achievement when groups are randomly formed as opposed to forming groups by subject preference.

6. As a question of true interest, the number of times a category of clue was changed in the program was examined and found to be a significant indicator of the skill in solving a problem. Consideration should be given to a study of the feasibility of training in a useful strategy for examining multiple bits of information. Some subjects proceeded from the first clue to the twentieth clue in order, others called for clues randomly with no organization at all. Is this a trainable skill?

7. Although this study was not conducted in a classroom setting, there are recommendations which may be helpful for a classroom teacher. Three study conclusions may suggest a useful direction for application:

(a) A microcomputer can be programmed to teach an effective interactive lesson and conduct successful practice sessions in selected problem-solving skills;

(b) Early adolescents learn quickly and easily how to operate the machine effectively; and,

(c) Informational data on the success of student efforts can be stored by the machine for later retrieval and evaluation.

These three elements together suggest that appropriate programming can be developed for efficient and effective use by a classroom teacher. Consideration should be given to the provision of competent programming resource personnel to develop specific aids for classroom teachers. Consideration should be given to a utilization schedule which includes assigning small teams of students to a time to interact with a microcomputer in either a corner of the classroom or in the media center, much as other independent instructional aids are used. Several questions emerge. Will all classroom teachers be interested in using a microcomputer? What are teacher attitudes concerning the use of microcomputers? Will the microcomputer be used primarily for duplication of tasks just as easily done with pencil and paper or will the creative potential of a computer as a "mind multiplier" (Billings, 1980) be tapped?

8. If microcomputers are indeed a viable, useful aid in problem-solving, educators at all levels should be made aware of microcomputer capabilities in the educational field. It is not enough to supply a microcomputer to teaching personnel and assume it will be fully utilized. This study has shown what can be done when a skilled programmer is accessible to adapt meaningful ideas and strategies which utilize the microcomputer capabilities.

### Implications for the Stapp and Cox Problem-Solving Model

The selected skills for this study were drawn from the Stapp and Cox 10-step problem-solving model. Subjects collected, organized and analyzed information, then generated alternative solutions

(Steps 4, 5, 6, and 7). As the study progressed, it became apparent that the fifth step, developing an action plan (Step 8), did not adequately describe the culmination of the research activity for the subjects. It appeared that from the alternative or possible solutions, subjects proceeded to evaluate, or test, each alternative solution against reality until one alternative solution was selected or developed as the most appropriate solution.

This observation of the subjects' procedural steps during the study has led the author to conclude that perhaps these two skills of (1) evaluating alternatives, and (2) selecting or developing the most appropriate solution have been assumed and inferred in the model, but were not stated as separate steps. With the inclusion of these steps, it would logically follow that after a solution was chosen, an action plan for change could be developed, implemented and evaluated (Steps 8, 9, and 10).

For clarity and completeness, consideration should be given to inserting two additional steps into the Stapp and Cox problem-solving model as follows, making it a 12-step sequence:

1. Recognize the problem,
2. Define the problem,
3. Listen with comprehension,
4. Collect information,
5. Organize information,
6. Analyze information,
7. Generate alternative solutions,
8. Evaluate the alternatives,
9. Select or develop the most appropriate solution,
10. Develop a plan of action,
11. Implement a plan of action, and
12. Evaluate the plan of action.

# APPENDICES

# APPENDIX A

## Cognitive Inventory

## COGNITIVE INVENTORY

Student I.D.__________
School__________
Date__________

The following questions are a part of the microcomputer research in which you are taking part. They will not be graded or affect your experience with the microcomputer in any way. So please be as honest as you can in giving your answers. You may guess or leave question responses blank if you do not know the answer.

Thank you for taking part.

I. Choose the best answer and put the letter on the blank line.

___ 1. How much experience have you had on a microcomputer?

- a. none
- b. played some games before this
- c. programmed some
- d. programmed a lot
- e. have a microcomputer at home

II. There are 5 different kinds of vertebrates in the animal kingdom. They are FISH, AMPHIBIANS, REPTILES, BIRDS and MAMMALS. Match the following to each category:

F = fish
A = amphibian
R = reptile
B = bird
M = mammal

Put the correct letter or letters on each blank line. You may use the terms as many times as needed.

___ ___ 2. No voice
___ ___ 3. Webbed feet
___ ___ 4. Take care of young ___
___ 5. Has no lungs
___ 6. Breathes through a moist skin
___ 7. Has hollow bones
___ ___ 8. Has air sacs

___ ___ 9. Young are born alive
___ ___ 10. Is warm blooded
___ ___ 11. Is cold blooded
___ ___ 12. Is soft to touch
___ 13. Is a champion jumper
___ ___ 14. Has scales
___ 15. Has a flexible hinge on jaws

Student I.D.__________

III. How much do you know about foreign travel, geography and cultures? Name the following. If you do not know any item, you may guess or leave it blank.

__________ 16. What country uses pesos for money?
__________ 17. In what country would you be likely to find an original Ming Vase?
__________ 18. In what country in the Western Hemisphere would you find pyramids?
__________ 19. In what country has the currency exchange rate doubled recently?
__________ 20. In what country is the Eiffel Tower?
__________ 21. In what country would you buy Limoges China?
__________ 22. In what country would you buy a sombrero?
__________ 23. In what Asian country would you find most everyone dressed alike?
__________ 24. In what country would you find the famous Hall of Mirrors?

IV. Let's see how much you know about the current energy situation. Answer the following questions. You may guess if you do not know the answer or leave the line blank.

__________ 25. What is the recommendation made by the President for daily room temperature?
__________ 26. Which fossil fuel is in the shortest supply and is likely to run out first?
__________ 27. What kind of fuel will be mined in great quantity in our Western States?
__________ 28. What fuel supply is controlled by the OPEC countries?
__________ 29. What fossil fuel is considered the cleanest fuel?

THANK YOU FOR YOUR HELP.

# APPENDIX B

## List of Problem and Clues for Microcomputer Program "Vertebrate Pets"

## LIST OF PROBLEM AND CLUES FOR MICROCOMPUTER PROGRAM "VERTEBRATE PETS"

### The Problem

Friday was visiting day for pets at Central School. Your task is to match each student's name with the kind of vertebrate each one brought to class.

### The Clues

#1 Two of the pets were warm blooded.

#2 Joe's and Ted's pets do not have a voice to make sounds.

#3 Two of the pets have webbed feet.

#4 Beth's and Mike's pets take good care of their young.

#5 Ted had to bring a special container for his pet because it has no lungs.

#6 Some of these facts may not be important to the solution of the problem.

#7 Ann's pet has lungs but it also must breathe through its moist skin.

#8 Hollow bones and air sacs make it easy for one pet to fly.

#9 Patti did not have a pet.

#10 Two of the pets have air sacs inside their bodies.

#11 Joe's and Mike's pets are born alive.

#12 One of the pets does not move around unless it is warm.

#13 The pets represented all five kinds of vertebrates: fish, amphibians, reptiles, birds, and mammals.

#14 Ted brought a cold-blooded pet.

#15 Ann's pet is the champion jumper of the group of pets.

#16 Two of the pets are soft to touch.

#17 Beth's pet has hollow bones.

#18 Two of the pets have scales.

#19 Mike brought a comb to keep his pet looking neat.

#20 Joe's pet has a long flexible hinge on its jaws to allow it to eat food bigger than its head size.

```
1 REM ** PET BASIC: VERTEBRATE PETS;
2 REM ** A LOGICAL REASONING GAME.
3 REM ** COPYRIGHT (C) 1979 BY
4 REM ** DOROTHY A. COX & JAMES M. COX
5 DIMA(20),Q$(75),Q(75)
6 GOSUB420
7 GOSUB272
8 PRINT"]▓▓▓▓FRIDAY WAS VISITING DAY FOR PETS AT"
9 PRINT"CENTRAL SCHOOL."
10 PRINT"▓▓▓▓YOUR TASK IS TO MATCH EACH STUDENT'S"
11 PRINT"NAME WITH THE KIND OF VERTEBRATE "
12 PRINT"EACH ONE BROUGHT TO CLASS."
13 GOSUB317
14 PRINT"]▓▓THERE ARE 20 CLUES. YOU MAY ASK FOR"
15 PRINT"THEM BY CATEGORY OR BY NUMBER AS MANY"
16 PRINT"TIMES AS YOU WISH."
17 PRINT"▓▓WHEN YOU CALL FOR A CLUE THE CLUE NUMBER"
18 PRINT"]WILL CHANGE COLOR"
19 PRINT"▓▓▓WHEN YOU THINK YOU HAVE THE SOLUTION,"
20 PRINT"CALL FOR CLUE # -2."
21 PRINT"▓WHEN YOU WANT TO GIVE UP, CALL FOR"
22 PRINT"CLUE # -1."
23 GOSUB317
24 PRINT"]▓REMEMBER:"
25 PRINT"YOUR TASK IS TO MATCH EACH STUDENT'S"
26 PRINT"NAME WITH THE KIND OF VERTEBRATE "
27 PRINT"EACH ONE BROUGHT TO CLASS."
28 PRINT"▓▓▓▓▓▓▓▓GOT THE SOLUTION? '-2' ; GIVE UP? '-1' "
29 GOSUB209
30 OPEN1,0,0:INPUT#1,A$:CLOSE1
31 X=VAL(A$):IFX=0THENPRINT"███  ███";:GOTO30
32 IFX=-1THENQ(M)=-1:GOTO290
33 IFX=-2THENQ(M)=-2:GOTO328
34 IFX>20THEN205
35 IFX<0ORX>20THEN226
36 IFINT(X)<>XTHEN226
37 IFX>10THENX=X-10:GOTO39
38 ONXGOTO40,47,55,62,70,78,86,94,102,109
39 ONXGOTO118,126,135,145,153,162,170,178,186,195
40 PRINT"▓▓▓▓▓▓▓▓▓▓▓▓▓CLUE # 1                                  "
41 PRINT"▓2 OF THE PETS WERE WARM BLOODED."
42 Q(M)=1
43 IFPEEK(33648)=177THENPOKE33648,49:GOTO45
44 POKE33648,177
45 A(1)=A(1)+1
46 GOTO225
47 PRINT"▓▓▓▓▓▓▓▓▓▓▓▓▓CLUE # 2                                  "
48 PRINT"▓JOE'S AND TED'S PETS DO NOT HAVE A"
49 PRINT"VOICE TO MAKE SOUNDS."
50 Q(M)=2
```

```
51 IFPEEK(33651)=178THENPOKE33651,50:GOTO53
52 POKE33651,178
53 A(2)=A(2)+1
54 GOTO225
55 PRINT"≋QQQQQQQQQQQCLUE # 3                                    "
56 PRINT"QTWO OF THE PETS HAVE WEBBED FEET."
57 Q(M)=3
58 IFPEEK(33654)=179THENPOKE33654,51:GOTO60
59 POKE33654,179
60 A(3)=A(3)+1
61 GOTO225
62 PRINT"≋QQQQQQQQQQQCLUE # 4                                    "
63 PRINT"QBETH'S AND MIKE'S PETS TAKE GOOD CARE"
64 PRINT"OF THEIR YOUNG."
65 Q(M)=4
66 IFPEEK(33657)=180THENPOKE33657,52:GOTO68
67 POKE33657,180
68 A(4)=A(4)+1
69 GOTO225
70 PRINT"≋QQQQQQQQQQQCLUE # 5                                    "
71 PRINT"QTED HAD TO BRING A SPECIAL CONTAINER FOR"
72 PRINT"TTHIS PET BECAUSE IT HAS NO LUNGS."
73 Q(M)=5
74 IFPEEK(33660)=181THENPOKE33660,53:GOTO76
75 POKE33660,181
76 A(5)=A(5)+1
77 GOTO225
78 PRINT"≋QQQQQQQQQQQCLUE # 6                                    "
79 PRINT"QSOME OF THESE FACTS MAY NOT BE IMPORTANT"
80 PRINT"TTO THE SOLUTION OF THE PROBLEM."
81 Q(M)=6
82 IFPEEK(33663)=182THENPOKE33663,54:GOTO84
83 POKE33663,182
84 A(6)=A(6)+1
85 GOTO225
86 PRINT"≋QQQQQQQQQQQCLUE # 7                                    "
87 PRINT"QANN'S PET HAS LUNGS BUT IT ALSO MUST"
88 PRINT"BREATHE THROUGH ITS MOIST SKIN."
89 Q(M)=7
90 IFPEEK(33666)=183THENPOKE33666,55:GOTO92
91 POKE33666,183
92 A(7)=A(7)+1
93 GOTO225
94 PRINT"≋QQQQQQQQQQQCLUE # 8                                    "
95 PRINT"QHOLLOW BONES AND AIR SACS MAKE IT EASY"
96 PRINT"FOR ONE PET TO FLY."
97 Q(M)=8
98 IFPEEK(33669)=184THENPOKE33669,56:GOTO100
99 POKE33669,184
100 A(8)=A(8)+1
```

```
101 GOTO225
102 PRINT"SQQQQQQQQQQCLUE # 9                           "
103 PRINT"QPATTI DID NOT HAVE A PET."
104 Q(M)=9
105 IFPEEK(33672)=185THENPOKE33672,57:GOTO107
106 POKE33672,185
107 A(9)=A(9)+1
108 GOTO225
109 PRINT"SQQQQQQQQQQCLUE # 10                          "
110 PRINT"QTWO OF THE PETS HAVE AIR SACS INSIDE"
111 PRINT"THEIR BODIES."
112 Q(M)=10
113 IFPEEK(33675)=177THENPOKE33675,49:POKE33676,48
114 GOTO116
115 POKE33675,177:POKE33676,176
116 A(10)=A(10)+1
117 GOTO225
118 PRINT"SQQQQQQQQQQCLUE # 11                          "
119 PRINT"QJOE'S AND MIKE'S PETS ARE BORN LIVE."
120 Q(M)=11
121 IFPEEK(33689)=177THENPOKE33689,49:POKE33690,49
122 GOTO124
123 POKE33689,177:POKE33690,177
124 A(11)=A(11)+1
125 GOTO225
126 PRINT"SQQQQQQQQQQCLUE # 12                          "
127 PRINT"QONE OF THE PETS DOES NOT MOVE AROUND"
128 PRINT"UNLESS IT IS WARM."
129 Q(M)=12
130 IFPEEK(33692)=177THENPOKE33692,49:POKE33693,50
131 GOTO133
132 POKE33692,177:POKE33693,178
133 A(12)=A(12)+1
134 GOTO225
135 PRINT"SQQQQQQQQQQCLUE # 13                          "
136 PRINT"QTHE PETS REPRESENTED ALL FIVE KINDS OF"
137 PRINT"VERTEBRATES: FISH, AMPHIBIANS, REPTILES,"
138 PRINT"]BIRDS, AND MAMMALS."
139 Q(M)=13
140 IFPEEK(33695)=177THENPOKE33695,49:POKE33696,51
141 GOTO143
142 POKE33695,177:POKE33696,179
143 A(13)=A(13)+1
144 GOTO225
145 PRINT"SQQQQQQQQQQCLUE # 14                          "
146 PRINT"QTED BROUGHT A COLD-BLOODED PET."
147 Q(M)=14
148 IFPEEK(33698)=177THENPOKE33698,49:POKE33699,52
149 GOTO151
150 POKE33698,177:POKE33699,180
```

184

```
151 A(14)=A(14)+1
152 GOTO225
153 PRINT"SQQQQQQQQQQCLUE # 15                            "
154 PRINT"QANN'S PET IS THE CHAMPION JUMPER OF"
155 PRINT"THE GROUP OF PETS."
156 Q(M)=15
157 IFPEEK(33701)=177THENPOKE33701,49:POKE33702,53
158 GOTO160
159 POKE33701,177:POKE33702,181
160 A(15)=A(15)+1
161 GOTO225
162 PRINT"SQQQQQQQQQQCLUE # 16                            "
163 PRINT"QTWO OF THE PETS ARE SOFT TO TOUCH."
164 Q(M)=16
165 IFPEEK(33704)=177THENPOKE33704,49:POKE33705,54
166 GOTO168
167 POKE33704,177:POKE33705,182
168 A(16)=A(16)+1
169 GOTO225
170 PRINT"SQQQQQQQQQQCLUE # 17                            "
171 PRINT"QBETH'S PET HAS HOLLOW BONES."
172 Q(M)=17
173 IFPEEK(33707)=177THENPOKE33707,49:POKE33708,55
174 GOTO176
175 POKE33707,177:POKE33708,183
176 A(17)=A(17)+1
177 GOTO225
178 PRINT"SQQQQQQQQQQCLUE # 18                            "
179 PRINT"QTWO OF THE PETS HAVE SCALES."
180 Q(M)=18
181 IFPEEK(33710)=177THENPOKE33710,49:POKE33711,56
182 GOTO184
183 POKE33710,177:POKE33711,184
184 A(18)=A(18)+1
185 GOTO225
186 PRINT"SQQQQQQQQQQCLUE # 19                            "
187 PRINT"QMIKE BROUGHT A COMB TO KEEP HIS PET"
188 PRINT"LOOKING NEAT."
189 Q(M)=19
190 IFPEEK(33713)=177THENPOKE33713,49:POKE33714,57
191 GOTO193
192 POKE33713,177:POKE33714,185
193 A(19)=A(19)+1
194 GOTO225
195 PRINT"SQQQQQQQQQQCLUE # 20                            "
196 PRINT"QJOE'S PET HAS A LONG FLEXIBLE HINGE ON"
197 PRINT"ITS JAWS TO ALLOW IT TO EAT FOOD BIGGER"
198 PRINT"]THAN ITS HEAD SIZE."
199 Q(M)=20
200 IFPEEK(33716)=178THENPOKE33716,50:POKE33717,48
```

```
201 GOTO203
202 POKE33716,178:POKE33717,176
203 A(20)=A(20)+1
204 GOTO225
205 PRINT"SQQQQQQQQQQ                           "
206 PRINT"QTHERE ARE ONLY 20 CLUES"
207 Q(M)=X
208 GOTO225
209 J=177
210 FORN=33648TO33672STEP3
211 POKEN,J
212 J=J+1
213 NEXTN
214 POKE33675,177
215 POKE33676,176
216 J=177
217 FORN=33689TO33713STEP3
218 POKEN,177
219 POKEN+1,J
220 J=J+1
221 NEXTN
222 POKE33716,178
223 POKE33717,176
224 GOTO226
225 GOSUB317
226 PRINT"SQQQQQ"
227 FORI=1TO13
228 PRINT"                                      ";
229 NEXTI
230 PRINT"SQQQQQQQQWHAT KIND OF CLUE DO YOU WANT:"
231 M=M+1
232 PRINT"]ABOUT A STUDENT?             TYPE 'S'"
233 PRINT"]ABOUT A PET CHARACTERISTIC? TYPE 'C'"
234 PRINT"]BY THE CLUE NUMBER?          TYPE 'N'";
235 GETA$:IFA$=""THEN235
236 Q$(M)=A$
237 IFA$="S"THEN241
238 IFA$="C"THEN248
239 IFA$="N"THEN264
240 GOTO235
241 PRINT"SQQQQQQQ"
242 FORI=1TO6
243 PRINT"                                     "
244 NEXTI
245 Z1=Z1+1
246 IFZ1=12THENZ1=1
247 ONZ1GOTO170,86,195,62,145,70,186,102,153,118,47
248 PRINT"SQQQQQQQ"
249 FORI=1TO6
250 PRINT"                                     "
```

```
251 NEXTI
252 Z2=Z2+1
253 IFZ2=19THENZ2=1
254 IFZ2>10THENZ2=Z2-10:GOTO256
255 ONZ2GOTO70,186,47,118,153,62,178,94,195,55
256 ONZ2GOTO162,109,170,135,40,126,86,145
257 PRINT"████████"
258 FORI=1TO6
259 PRINT"                                              "
260 NEXTI
261 Z3=Z3+1
262 IFZ3=6THENZ3=1
263 ONZ3GOTO162,55,126,178,109
264 PRINT"█████████████████████████████";
265 PRINT"█ PRESS RETURN TO CONTINUE █"
266 PRINT"████████"
267 FORI=1TO6
268 PRINT"                                              "
269 NEXTI
270 PRINT"████████████WHAT CLUE WOULD YOU LIKE? ";
271 GOTO30
272 PRINT"█"
273 A=32768:B=A:C=33767:D=C:E=127
274 FORI=1TO39
275 POKEA,E:POKEB,E:POKEC,E:POKED,E
276 IFI<25THENA=A+1:B=B+40:C=C-1:D=D-40
277 IFI>24THENA=A+1:C=C-1
278 NEXTI
279 PRINTTAB(11)"███VERTEBRATE PETS"
280 PRINT"███████████THIS IS AN EXERCISE IN"
281 PRINT"██████████LOGIC AND REASONING."
282 PRINT"████████WRITTEN BY    DOROTHY A. COX"
283 PRINT"██████PROGRAMMED BY   JAMES M. COX"
284 GOSUB317
285 RETURN
286 FORN=1TO20
287 A(N)=0
288 NEXTN
289 RETURN
290 W$="GAVE UP"
291 PRINT"██████    STUDENT          KIND OF VERTEBRATE"
292 PRINT"───────────────┼──────────────────────────────"
293 PRINT"               |"
294 PRINT"      JOE      |         REPTILE"
295 PRINT"      TED      |         FISH"
296 PRINT"      BETH     |         BIRD"
297 PRINT"      MIKE     |         MAMMAL"
298 PRINT"      ANN      |         AMPHIBIAN"
299 PRINT"      PATTI    |         NONE"
300 GOSUB317
```

```
301 PRINT"⊐"
302 FORL=1TO20:A(0)=A(0)+A(L):NEXTL
303 PRINT"⊐◘◘◘YOU CALLED FOR ";A(0);" CLUES"
304 GOSUB317
305 PRINT"⊐"
306 FORK=1TO20
307 PRINT"YOU CALLED FOR CLUE #";
308 IFK<10THENPRINT" ";
309 PRINTK;A(K);"TIME(S)"
310 NEXTK
311 PRINT"◘◘◘"
312 GOSUB317
313 T3=TI
314 PRINT"⊐◘◘◘THANK YOU FOR PARTICIPATING IN THIS"
315 PRINT"PROJECT."
316 GOTO457
317 B$="▣"
318 A$=" PRESS RETURN TO CONTINUE "
319 PRINT"◙◘◘◘◘◘◘◘◘◘◘◘◘◘◘◘◘◘▮▮▮▮▌";A$
320 GETC$:IFC$=""THEN327
321 IFC$<>CHR$(13)THEN320
322 PRINT"◙◘◘◘◘◘◘◘◘◘◘◘◘◘◘◘◘◘▮▮▮▮▌
323 RETURN
324 A$=B$+A$:GOTO319
325 C=C+1:IFC=INT(C/2)*2THEN324
326 GOTO318
327 FORP=1TO250:NEXT:GOTO325
328 CC1=0
329 PRINT"⊐    STUDENT         KIND OF VERTEBRATE"
330 PRINT"───────────────┼───────────────────────"
331 FORK=1TO7
332 PRINTTAB(16)"|"
333 NEXTK
334 K=0
335 PRINT"◘◘◘◘◘WHAT IS THE NAME OF ONE OF THE STUDENTS"
336 OPEN1,0,0:INPUT#1,A1$:CLOSE1
337 IFA1$=""THEN336
338 IFA1$="JOE" OR A1$="TED" OR A1$="BETH"THEN345
339 IFA1$="MIKE" OR A1$="ANN" OR A1$="PATTI"THEN345
340 PRINT"▣I'M SORRY, ";A1$;"▣ IS NOT CORRECT■"
341 FORP=1TO1000:NEXT
342 IFK=0THEN GOSUB415:K=1:PRINT"◙◘◘◘◘◘◘◘"; :GOTO335
343 PRINT"◘▣ YOU NEED TO SEE MORE CLUES ■"
344 FORP=1TO3000:NEXT:GOTO24
345 GOSUB388
346 PRINT"▣ THAT IS CORRECT! ■":FORP=1TO1000:NEXT
347 IFPEEK(32894)=32THENPRINT"◙◘◘◘▮▮▮▮▌";A1$:GOTO353
348 IFPEEK(32934)=32THENPRINT"◙◘◘◘◘▮▮▮▮▌";A1$:GOTO353
349 IFPEEK(32974)=32THENPRINT"◙◘◘◘◘◘▮▮▮▮▌";A1$:GOTO353
350 IFPEEK(33014)=32THENPRINT"◙◘◘◘◘◘◘▮▮▮▮▌";A1$:GOTO353
```

155

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351 IFPEEK(33054)=32THENPRINT"SQQQQQQQQ]]]]]]";A1$:GOTO353
352 IFPEEK(33094)=32THENPRINT"SQQQQQQQQQ]]]]]]";A1$
353 GOSUB415
354 K=0
355 PRINT"SQQQQQQQQQQQQQ"
356 PRINT"WHAT KIND OF VERTEBRATE WAS ";A1$;"'S PET"
357 OPEN1,0,0:INPUT#1,A3$:CLOSE1
358 IFA3$=""THEN357
359 GOSUB406
360 IFA1$="JOE"ANDA3$="REPTILE"THEN371
361 IFA1$="TED"ANDA3$="FISH"THEN371
362 IFA1$="BETH"ANDA3$="BIRD"THEN371
363 IFA1$="MIKE"ANDA3$="MAMMAL"THEN371
364 IFA1$="ANN"ANDA3$="AMPHIBIAN"THEN371
365 IFA1$="PATTI"THENA3$="NONE":GOTO371
366 PRINT"RI'M SORRY, ";A3$;"R IS NOT CORRECT■"
367 FORP=1TO1000:NEXT
368 IFK=0THENGOSUB415:K=1:PRINT"SQQQQQQQQQQQQQQQ";:GOTO356
369 PRINT"QR YOU NEED TO SEE MORE CLUES ■"
370 FORP=1TO3000:NEXT:GOTO24
371 PRINT"R THAT IS CORRECT! ■":FORP=1TO1000:NEXT
372 IFPEEK(32912)=32THENPRINT"SQQQ"TAB(21)A3$:GOTO378
373 IFPEEK(32952)=32THENPRINT"SQQQQ"TAB(21)A3$:GOTO378
374 IFPEEK(32992)=32THENPRINT"SQQQQQ"TAB(21)A3$:GOTO378
375 IFPEEK(33032)=32THENPRINT"SQQQQQQ"TAB(21)A3$:GOTO378
376 IFPEEK(33072)=32THENPRINT"SQQQQQQQ"TAB(21)A3$:GOTO378
377 IFPEEK(33112)=32THENPRINT"SQQQQQQQQ"TAB(21)A3$
378 GOSUB415
379 CC1=CC1+1
380 IFCC1<>6THENK=0:GOTO386
381 FORP=1TO2000:NEXT
382 PRINT"SQQQQQQQQQQQQQQQQ]]]]]]]R YOU SOLVED THE PROBLEM!!! ■"
383 FORP=1TO3000:NEXT
384 W$="PROBLEM SOLVED"
385 GOTO301
386 PRINT"SQQQQQQQQQQQQQQQQQWHAT IS THE NAME OF ANOTHER STUDENT"
387 GOTO336
388 A4$(CC1+1)=A1$
389 FORI=0TOCC1
390 IFA1$=A4$(I)THEN393
391 NEXTI
392 GOTO346
393 PRINT"RBUT YOU ALREADY GAVE THAT ANSWER!■"
394 FORP=1TO 2000:NEXT
395 GOSUB415
396 GOTO386
397 A5$(CC1+1)=A2$
398 FORI=0TOCC1
399 IFA2$=A5$(I)THEN402
400 NEXTI
```

```
401 RETURN
402 PRINT"■BUT YOU ALREADY GAVE THAT ANSWER!■"
403 FORP=1TO 2000:NEXT
404 GOSUB415
405 GOTO355
406 A6$(CC1+1)=A3$
407 FORI=0TOCC1
408 IFA3$=A6$(I)THEN411
409 NEXTI
410 RETURN
411 PRINT"■BUT YOU ALREADY GAVE THAT ANSWER!■"
412 FORP=1TO 2000:NEXT
413 GOSUB415
414 GOTO355
415 PRINT"■■■■■■■■■■■■■"
416 FORQ=1TO6
417 PRINT"                                        "
418 NEXTQ
419 RETURN
420 PRINT"■YOU ARE PART OF A RESEARCH PROJECT.":GOSUB455
421 PRINT "■■THIS GAME TODAY IS ONE OF THREE GAMES"
422 PRINT "YOU WILL BE ASKED TO SOLVE.":GOSUB456
423 PRINT "■■SOME OF YOU WILL BE WORKING ALONE"
424 PRINT "AND SOME OF YOU WILL BE WORKING WITH"
425 PRINT "OTHER STUDENTS TO SOLVE A PROBLEM ON"
426 PRINT "ON THIS MICROCOMPUTER.":GOSUB456
427 PRINT "■■THE COMPUTER WILL KEEP TRACK OF"
428 PRINT "HOW LONG IT TAKES YOU TO SOLVE THE "
429 PRINT "PROBLEM AND HOW MANY CLUES YOU ASK FOR.":GOSUB456
430 GOSUB456
431 PRINT "■GOOD LUCK!  HAVE FUN!"
432 PRINT "THANK YOU FOR VOLUNTEERING.":GOSUB 482
433 D1$="VERTEBRATE PETS"
434 PRINT"■■■■■■HOW MANY ARE IN YOUR GROUP ";
435 OPEN1,0,0:INPUT#1,E$:IFE$=""THEN435
436 T1=VAL(E$):CLOSE1
437 PRINT:PRINT"■■WHAT IS THE DATE TODAY ";
438 OPEN1,0,0:INPUT#1,D2$:CLOSE1:IFD2$=""THEN438
439 FORI=1TOT1
440 PRINT"■■■■■"
441 PRINT"■■STUDENT #";I
442 PRINT:PRINT"WHAT IS YOUR ID ";
443 OPEN1,0,0:INPUT#1,E$:ID(I)=VAL(E$):IFE$=""THEN443
444 PRINT:PRINT"■WHAT IS YOUR GRADE ";
445 INPUT#1,E$:G(I)=VAL(E$):IFE$=""THEN445
446 PRINT:PRINT"■WHAT IS YOUR AGE ";
447 INPUT#1,E$:E1(I)=VAL(E$):IFE$=""THEN447
448 PRINT:PRINT"■WHAT IS YOUR SEX ";
449 INPUT#1,S$(I):IFS$(I)=""THEN449
450 PRINT:PRINT"■HOW MANY PROJECT GAMES HAVE YOU PLAYED ";
```

```
451 INPUT#1,E$:CLOSE1:B(I)=VAL(E$):IFE$=""THEN451
452 NEXTI
453 T2=TI
454 RETURN
455 FORP=1TO2500:NEXT:RETURN
456 FORP=1TO5000:NEXT:RETURN
457 FORP=1TO1500:NEXT:PRINT"J"
458 OPEN11,1,1
459 PRINT#11,M
460 PRINT#11,D1$
461 PRINT#11,D2$
462 PRINT#11,T1
463 PRINT#11,W$
464 PRINT#11,T2
465 PRINT#11,T3
466 FORI=1TOT1
467 PRINT#11,ID(I)
468 PRINT#11,G(I)
469 PRINT#11,E1(I)
470 PRINT#11,S$(I)
471 PRINT#11,B(I)
472 NEXTI
473 FORI=1TOM
474 PRINT#11,Q$(I)
475 PRINT#11,Q(I)
476 NEXTI
477 FORI=0TO20
478 PRINT#11,A(I)
479 NEXTI
480 CLOSE11
481 END
482 B$="Q"
483 A$="PRESS RETURN TO CONTINUE"
484 PRINT"SQQQQQQQQQQQQQQQQQQQQQQQ]]]]]]]]I";A$
485 GETC$:IFC$=""THEN492
486 IFC$<>CHR$(13)THEN485
487 PRINT"SQQQQQQQQQQQQQQQQQQQQQQQ]]]]]]]]I"
488 RETURN
489 A$=B$+A$:GOTO484
490 C=C+1:IFC=INT(C/2)*2THEN489
491 GOTO483
492 FORP=1TO250:NEXT:GOTO490
```

# APPENDIX C

## List of Problem and Clues for Microcomputer Program "Energy at Home"

## LIST OF PROBLEM AND CLUES FOR MICROCOMPUTER PROGRAM "ENERGY AT HOME"

### The Problem

Three teachers meet on the last Tuesday of the month to play cards.

Your task is to match the name of each teacher with the kind of fuel they burn and the temperature setting in each home.

### The Clues

#1 Ms. Brown follows the presidential recommendation for a desirable room temperature.

#2 One of the teachers knows that his fuel resource will probably run out within the next decade or two.

#3 There is a central heating system in Ms. Lawrence's apartment and she can't control the level of her heat.

#4 Everyone wears a sweater when they visit Mr. Jones in his home.

#5 The apartment building manager will soon be getting fuel from the western states.

#6 There is a difference of five degrees in the room temperature of two of the houses.

#7 A very large supply of coal shale has been discovered in our western states.

#8 The difference in Mr. Jones' and Ms. Lawrence's home temperature is twice as much as the difference of Ms. Brown's and Ms. Lawrence's.

#9 Ms. Brown worries about the O.P.E.C. countries decisions.

#10 The apartment building is 5 degrees warmer than Ms. Brown's house.

#11 Mr. Jones' heating bill is less than his two teaching friends.

#12 Ms. Brown insulated her house last fall and has cut her heating bill in half.

#13 Mr. Jones chose the cleanest fuel available.

#14 The teacher who likes sweaters is worried about their fuel supply and is planning to install solar panels.

#15 Ms. Lawrence often wears shorts and goes barefoot in her apartment on the coldest winter day.

#16 Ms. Brown set her thermostat 5 degrees higher than Mr. Jones.

#17 Natural gas is considered the cleanest of the available fuels.

#18 Ms. Brown feels too warm at Ms. Lawrence's house.

#19 Many believe that our supply of natural gas will be the first to run out.

#20 The presidential recommendation for desirable daytime temperature is 68 degrees.

```
1 REM *** PET BASIC: ENERGY AT HOME;
2 REM *** A LOGICAL REASONING GAME.
3 REM *** COPYRIGHT (C) 1979 BY
4 REM *** DOROTHY A. COX & JAMES M. COX
5 DIMA(20),Q(75),Q$(75)
6 FORI=1TO9:A5$(I)="":NEXT
7 FORI=1TO9:A6$(I)="":NEXT
8 FORI=1TO9:A7$(I)="":NEXT
9 FORI=1TO9:A8$(I)="":NEXT
10 GOSUB457:GOSUB297
11 PRINT"■■■■■THREE TEACHERS MEET ON THE LAST TUESDAY"
12 PRINT "OF THE MONTH TO PLAY CARDS."
13 PRINT"■■■■YOUR TASK IS TO:"
14 PRINT"■  MATCH THE NAME OF EACH TEACHER"
15 PRINT"  WITH THE KIND OF FUEL THEY BURN"
16 PRINT"  AND THE TEMPERATURE SETTING"
17 PRINT"  IN EACH HOME."
18 GOSUB339
19 PRINT"■■■THERE ARE 20 CLUES. YOU MAY ASK FOR"
20 PRINT"THEM BY CATEGORY OR BY NUMBER AS MANY"
21 PRINT"TIMES AS YOU WISH."
22 PRINT"■■WHEN YOU CALL FOR A CLUE THE CLUE NUMBER"
23 PRINT"WILL CHANGE COLOR"
24 PRINT"■■■WHEN YOU THINK YOU HAVE THE SOLUTION,"
25 PRINT"CALL FOR CLUE # -2."
26 PRINT"■WHEN YOU WANT TO GIVE UP, CALL FOR"
27 PRINT"CLUE # -1."
28 GOSUB339
29 PRINT"■■■REMEMBER:■YOUR TASK IS TO:"
30 PRINT"  MATCH EACH TEACHER'S NAME"
31 PRINT"  WITH THE KIND OF FUEL THEY BURN,"
32 PRINT"  AND THE TEMPERATURE SETTING"
33 PRINT"  IN EACH HOME."
34 PRINT"■■■■■■■■■GOT THE SOLUTION?'-2'■;  ■GIVE UP? '-1' "
35 GOSUB224
36 OPEN1,0,0:INPUT#1,A$:CLOSE1
37 X=VAL(A$):IFX=0THENPRINT"■■■  ■■■";:GOTO36
38 IFX=-1THENQ(M)=-1:GOTO315
39 IFX=-2THENQ(M)=-2:GOTO350
40 IFX>20THEN220
41 IFX<0ORX>20THEN241
42 IFINT(X)<>XTHEN241
43 IFX>10THENX=X-10:GOTO45
44 ONXGOTO46,55,64,74,82,91,100,108,118,126
45 ONXGOTO134,142,150,158,167,176,184,192,200,208
46 PRINT"■■■■■■■■■■■■CLUE # 1                      ■"
47 PRINT"MS. BROWN FOLLOWS THE PRESIDENTIAL    "
48 PRINT"RECOMMENDATION FOR A DESIRABLE ROOM   "
49 PRINT"TEMPERATURE."
50 Q(M)=1
```

```
51 IFPEEK(33648)=177THENPOKE33648,49:GOTO53
52 POKE33648,177
53 A(1)=A(1)+1
54 GOTO240
55 PRINT"███████████CLUE # 2                             █"
56 PRINT"ONE OF THE TEACHERS KNOWS THAT HIS    "
57 PRINT"FUEL RESOURCE WILL PROBABLY RUN OUT    "
58 PRINT"WITHIN THE NEXT DECADE OR TWO."
59 Q(M)=2
60 IFPEEK(33651)=178THENPOKE33651,50:GOTO62
61 POKE33651,178
62 A(2)=A(2)+1
63 GOTO240
64 PRINT"███████████CLUE # 3                             █"
65 PRINT"THERE IS A CENTRAL HEATING SYSTEM IN   "
66 PRINT"MS. LAWRENCE'S APARTMENT BUILDING AND "
67 PRINT"SHE CAN'T CONTROL THE LEVEL OF HER"
68 PRINT"HEAT."
69 Q(M)=3
70 IFPEEK(33654)=179THENPOKE33654,51:GOTO72
71 POKE33654,179
72 A(3)=A(3)+1
73 GOTO240
74 PRINT"███████████CLUE # 4                             █"
75 PRINT"EVERYONE WEARS A SWEATER WHEN THEY"
76 PRINT"VISIT MR. JONES IN HIS HOUSE."
77 Q(M)=4
78 IFPEEK(33657)=180THENPOKE33657,52:GOTO80
79 POKE33657,180
80 A(4)=A(4)+1
81 GOTO240
82 PRINT"███████████CLUE # 5                             █"
83 PRINT"THE APARTMENT BUILDING MANAGER WILL"
84 PRINT"SOON BE GETTING FUEL FROM THE WESTERN"
85 PRINT"STATES."
86 Q(M)=5
87 IFPEEK(33660)=181THENPOKE33660,53:GOTO89
88 POKE33660,181
89 A(5)=A(5)+1
90 GOTO240
91 PRINT"███████████CLUE # 6                             █"
92 PRINT"THERE IS A DIFFERENCE OF FIVE DEGREES"
93 PRINT"IN THE ROOM TEMPERATURE OF TWO OF THE"
94 PRINT"HOUSES."
95 Q(M)=6
96 IFPEEK(33663)=182THENPOKE33663,54:GOTO98
97 POKE33663,182
98 A(6)=A(6)+1
99 GOTO240
100 PRINT"███████████CLUE # 7                             █"
```

```
101 PRINT"A VERY LARGE SUPPLY OF COAL SHALE HAS"
102 PRINT"BEEN DISCOVERED IN OUR WESTERN STATES."
103 Q(M)=7
104 IFPEEK(33666)=183THENPOKE33666,55:GOTO106
105 POKE33666,183
106 A(7)=A(7)+1
107 GOTO240
108 PRINT"[illegible]CLUE # 8                            [illegible]"
109 PRINT"THE DIFFERENCE IN MR. JONES' AND MS."
110 PRINT"LAWRENCE'S HOME TEMPERATURE IS TWICE AS"
111 PRINT"MUCH AS THE DIFFERENCE OF MS. BROWN'S"
112 PRINT"AND MS. LAWRENCE'S."
113 Q(M)=8
114 IFPEEK(33669)=184THENPOKE33669,56:GOTO116
115 POKE33669,184
116 A(8)=A(8)+1
117 GOTO240
118 PRINT"[illegible]CLUE # 9                            [illegible]"
119 PRINT"MS. BROWN WORRIES ABOUT THE O.P.E.C."
120 PRINT"COUNTRIES DECISIONS."
121 Q(M)=9
122 IFPEEK(33672)=185THENPOKE33672,57:GOTO124
123 POKE33672,185
124 A(9)=A(9)+1
125 GOTO240
126 PRINT"[illegible]CLUE # 10                           [illegible]"
127 PRINT"THE APARTMENT BUILDING IS 5 DEGREES"
128 PRINT"WARMER THAN MS. BROWN HOUSE."
129 Q(M)=10
130 IFPEEK(33675)=177THENPOKE33675,49:POKE33676,48:GOTO132
131 POKE33675,177:POKE33676,176
132 A(10)=A(10)+1
133 GOTO240
134 PRINT"[illegible]CLUE # 11                           [illegible]"
135 PRINT"MR. JONES' HEATING BILL IS LESS THAN"
136 PRINT"HIS TWO TEACHING FRIENDS."
137 Q(M)=11
138 IFPEEK(33689)=177THENPOKE33689,49:POKE33690,49:GOTO140
139 POKE33689,177:POKE33690,177
140 A(11)=A(11)+1
141 GOTO240
142 PRINT"[illegible]CLUE # 12                           [illegible]"
143 PRINT"MS. BROWN INSULATED HER HOUSE LAST FALL"
144 PRINT"AND HAS CUT HER HEATING BILL IN HALF."
145 Q(M)=12
146 IFPEEK(33692)=177THENPOKE33692,49:POKE33693,50:GOTO148
147 POKE33692,177:POKE33693,178
148 A(12)=A(12)+1
149 GOTO240
150 PRINT"[illegible]CLUE # 13                           [illegible]"
```

```
151 PRINT"MR. JONES CHOSE THE CLEANEST FUEL"
152 PRINT"AVAILABLE."
153 Q(M)=13
154 IFPEEK(33695)=177THENPOKE33695,49:POKE33696,51:GOTO156
155 POKE33695,177:POKE33696,179
156 A(13)=A(13)+1
157 GOTO240
158 PRINT"▒▒▒▒▒▒▒▒▒▒▒▒CLUE # 14                               ▒"
159 PRINT"THE TEACHER WHO LIKES SWEATERS IS"
160 PRINT"WORRIED ABOUT THEIR FUEL SUPPLY AND"
161 PRINT"IS PLANNING TO INSTALL SOLAR PANELS."
162 Q(M)=14
163 IFPEEK(33698)=177THENPOKE33698,49:POKE33699,52:GOTO165
164 POKE33698,177:POKE33699,180
165 A(14)=A(14)+1
166 GOTO240
167 PRINT"▒▒▒▒▒▒▒▒▒▒▒▒CLUE # 15                               ▒"
168 PRINT"MS. LAWRENCE OFTEN WEARS SHORTS AND"
169 PRINT"GOES BAREFOOT IN HER APARTMENT ON THE"
170 PRINT"COLDEST WINTER DAY."
171 Q(M)=15
172 IFPEEK(33701)=177THENPOKE33701,49:POKE33702,53:GOTO174
173 POKE33701,177:POKE33702,181
174 A(15)=A(15)+1
175 GOTO240
176 PRINT"▒▒▒▒▒▒▒▒▒▒▒▒CLUE # 16                               ▒"
177 PRINT"MS. BROWN▒SET HER THERMOSTAT 5 DEGREES"
178 PRINT"HIGHER THAN MR. JONES."
179 Q(M)=16
180 IFPEEK(33704)=177THENPOKE33704,49:POKE33705,54:GOTO182
181 POKE33704,177:POKE33705,182
182 A(16)=A(16)+1
183 GOTO240
184 PRINT"▒▒▒▒▒▒▒▒▒▒▒▒CLUE # 17                               ▒"
185 PRINT"NATURAL GAS IS CONSIDERED THE CLEANEST"
186 PRINT"OF THE AVAILABLE FUELS."
187 Q(M)=17
188 IFPEEK(33707)=177THENPOKE33707,49:POKE33708,55:GOTO190
189 POKE33707,177:POKE33708,183
190 A(17)=A(17)+1
191 GOTO240
192 PRINT"▒▒▒▒▒▒▒▒▒▒▒▒CLUE # 18                               ▒"
193 PRINT"MS. BROWN FEELS TOO WARM AT"
194 PRINT"MS. LAWRENCE´S HOUSE."
195 Q(M)=18
196 IFPEEK(33710)=177THENPOKE33710,49:POKE33711,56:GOTO198
197 POKE33710,177:POKE33711,184
198 A(18)=A(18)+1
199 GOTO240
200 PRINT"▒▒▒▒▒▒▒▒▒▒▒▒CLUE # 19                               ▒"
```

```
201 PRINT"MANY BELIEVE THAT OUR SUPPLY OF NATURAL"
202 PRINT"GAS WILL BE THE FIRST TO RUN OUT."
203 Q(M)=19
204 IFPEEK(33713)=177THENPOKE33713,49:POKE33714,57:GOTO206
205 POKE33713,177:POKE33714,185
206 A(19)=A(19)+1
207 GOTO240
208 PRINT"[illegible]CLUE # 20                               [illegible]"
209 PRINT"THE PRESIDENTIAL RECOMMENDATION FOR"
210 PRINT"DESIRABLE DAYTIME TEMPERATURE IS 68"
211 PRINT"DEGREES."
212 Q(M)=20
213 IFPEEK(33716)=178THENPOKE33716,50:POKE33717,48:GOTO215
214 POKE33716,178:POKE33717,176
215 A(20)=A(20)+1
216 GOTO240
217 PRINT"[illegible]CLUE # 17                               [illegible]"
218 PRINT"NATURAL GAS IS CONSIDERED THE CLEANEST"
219 PRINT"OF THE AVAILABLE FUELS."
220 PRINT"[illegible]                               "
221 PRINT"[illegible]THERE ARE ONLY 20 CLUES"
222 Q(M)=X
223 GOTO240
224 J=177
225 FORN=33648TO33672STEP3
226 POKEN,J
227 J=J+1
228 NEXTN
229 POKE33675,177
230 POKE33676,176
231 J=177
232 FORN=33689TO33713STEP3
233 POKEN,177
234 POKEN+1,J
235 J=J+1
236 NEXTN
237 POKE33716,178
238 POKE33717,176
239 GOTO241
240 GOSUB339
241 PRINT"[illegible]"
242 FORI=1TO12
243 PRINT"                                       "
244 NEXTI
245 PRINT"[illegible]
246 PRINT"[illegible]WHAT KIND OF CLUE DO YOU WANT:[illegible]"
247 M=M+1
248 PRINT"ABOUT A TEACHER?            TYPE 'T'"
249 PRINT"ABOUT A TEMP. SETTING?      TYPE 'S'"
250 PRINT"ABOUT A KIND OF FUEL?       TYPE 'F'"
```

```
251 PRINT"ABOUT CONSERVING FUEL?     TYPE 'C'"
252 PRINT"BY THE CLUE NUMBER?        TYPE 'N'";
253 GETA$:IFA$=""THEN253
254 Q$(M)=A$
255 IFA$="T"THEN261
256 IFA$="S"THEN275
257 IFA$="F"THEN268
258 IFA$="C"THEN282
259 IFA$="N"THEN289
260 GOTO253
261 PRINT"■■■■■■■■■"
262 FORI=1TO10
263 PRINT"                                      "
264 NEXTI
265 Z0=Z0+1
266 IFZ0=14THENZ0=1
267 ONZ0GOTO108,142,64,192,126,118,158,134,176,46,150,167,74
268 PRINT"■■■■■■■■■"
269 FORI=1TO10
270 PRINT"                                      "
271 NEXTI
272 Z1=Z1+1
273 IFZ1=9THENZ1=1
274 ONZ1GOTO150,100,55,118,184,200,158,82
275 PRINT"■■■■■■■■■"
276 FORI=1TO10
277 PRINT"                                      "
278 NEXTI
279 Z2=Z2+1
280 IFZ2=11THENZ2=1
281 ONZ2GOTO167,108,192,64,91,208,74,176,126,46
282 PRINT"■■■■■■■■■"
283 FORI=1TO10
284 PRINT"                                      "
285 NEXTI
286 Z3=Z3+1
287 IFZ3=4THENZ3=1
288 ONZ3GOTO134,158,142
289 PRINT"■■■■■■■■■■■■■■■■■■■■■■■■■■";
290 PRINT"■ PRESS RETURN TO CONTINUE ■"
291 PRINT"■■■■■■■■"
292 FORI=1TO13
293 PRINT"                                     "
294 NEXTI
295 PRINT"■■■■■■■■■■■WHAT CLUE WOULD YOU LIKE? ";
296 GOTO36
297 PRINT"■"
298 A=32768:B=A:C=33767:D=C:E=127
299 FORI=1TO39
300 POKEA,E:POKEB,E:POKEC,E:POKED,E
```

```
301 IFI<25THENA=A+1:B=B+40:C=C-1:D=D-40
302 IFI>24THENA=A+1:C=C-1
303 NEXTI
304 PRINTTAB(11)"▒▒▒ENERGY AT HOME"
305 PRINT"▒▒▒▒▒▒▒▒THIS IS AN EXERCISE IN"
306 PRINT"▒▒▒▒▒▒▒LOGIC AND REASONING."
307 PRINT"▒▒▒▒▒▒WRITTEN BY    DOROTHY A. COX"
308 PRINT"▒▒▒▒▒PROGRAMMED BY   JAMES M. COX"
309 GOSUB339
310 RETURN
311 FORN=1TO20
312 A(N)=0
313 NEXTN
314 RETURN
315 W$="GAVE UP"
316 PRINT"▒▒▒▒ TEACHER      FUEL BURNED TEMP.SETTING"
317 PRINT"──────────────┼────────────┼─────────────"
318 PRINT"              |            |"
319 PRINT"MS. LAWRENCE| COAL       |   73"
320 PRINT"MS. BROWN   | OIL        |   68"
321 PRINT"MR. JONES   | NAT. GAS   |   63"
322 GOSUB339
323 PRINT"▒"
324 FORL=1TO20:A(0)=A(0)+A(L):NEXTL
325 PRINT"▒▒▒YOU CALLED FOR ";A(0);" CLUES"
326 GOSUB339
327 PRINT"▒"
328 FORK=1TO20
329 PRINT"YOU CALLED FOR CLUE #";
330 IFK<10THENPRINT" ";
331 PRINTK;A(K);"TIME(S)"
332 NEXTK
333 PRINT"▒▒"
334 GOSUB339
335 T3=TI
336 PRINT"▒▒▒THANK YOU FOR PARTICIPATING IN THIS "
337 PRINT"PROJECT."
338 GOTO496
339 B$="▒"
340 A$=" PRESS RETURN TO CONTINUE "
341 PRINT"▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒";A$
342 GETC$:IFC$=""THEN349
343 IFC$<>CHR$(13)THEN342
344 PRINT"▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒
345 RETURN
346 A$=B$+A$:GOTO341
347 C=C+1:IFC=INT(C/2)*2THEN346
348 GOTO340
349 FORP=1TO250:NEXT:GOTO347
350 CC1=0
```

```
351 PRINT"⊐ TEACHER      FUEL BURNED TEMP.SETTING"
352 PRINT"────────────┼────────────┼────────────"
353 PRINT"            │            │"
354 PRINT"            │            │"
355 PRINT"            │            │"
356 PRINT"            │            │"
357 K=0
358 PRINT"███████████████";
359 PRINT"WHAT IS THE NAME OF A TEACHER?"
360 OPEN1,0,0:INPUT#1,A1$:CLOSE1
361 IFA1$=""THEN360
362 IFA1$="MS. LAWRENCE"  THEN370
363 IFA1$="MS. BROWN" OR A1$="MR. JONES"THEN370
364 PRINT:PRINT"██I´M SORRY, ";A1$;" IS NOT CORRECT"
365 FORP=1TO4500:NEXT
366 IFK=0ANDCC1=0THEN GOSUB449:K=1:GOTO358
367 IFK=0ANDCC1<>0THENGOSUB449:K=1:GOTO426
368 PRINT:PRINT"██ YOU NEED TO SEE MORE CLUES █"
369 FORP=1TO3000:NEXT:GOTO29
370 GOSUB429
371 PRINT:PRINT"██ THAT IS CORRECT! █"
372 FORP=1TO1000:NEXT
373 IFPEEK(32848)=32THENPRINT"███";A1$:GOTO376
374 IFPEEK(32888)=32THENPRINT"████";A1$:GOTO376
375 IFPEEK(32928)=32THENPRINT"█████";A1$:GOTO376
376 GOSUB449
377 K=0
378 PRINT"█████████████"
379 PRINT"WHAT KIND OF FUEL DOES "A1$" BURN"
380 OPEN1,0,0:INPUT#1,A2$:CLOSE1
381 IFA2$=""THEN380
382 IFA2$="NATURAL GAS"THENA2$="NAT. GAS"
383 IFA2$="GAS"THENA2$="NAT. GAS"
384 IFA1$="MS. LAWRENCE"ANDA2$="COAL"THEN392
385 IFA1$="MS. BROWN"ANDA2$="OIL"THEN392
386 IFA1$="MR. JONES"ANDA2$="NAT. GAS"THEN392
387 PRINT:PRINT"██I´M SORRY, ";A2$;" IS NOT CORRECT"
388 FORP=1TO4500:NEXT
389 IFK=0THENGOSUB449:K=1:GOTO378
390 PRINT:PRINT"██ YOU NEED TO SEE MORE CLUES █"
391 FORP=1TO3000:NEXT:GOTO29
392 PRINT:PRINT"██ THAT IS CORRECT! █":FORP=1TO1000:NEXT
393 IFPEEK(32862)=32THENPRINT"███"TAB(14)A2$:GOTO396
394 IFPEEK(32902)=32THENPRINT"████"TAB(14)A2$:GOTO396
395 IFPEEK(32942)=32THENPRINT"█████"TAB(14)A2$:GOTO396
396 GOSUB449:K=0
397 PRINT"█████████████"
398 PRINT"WHAT IS THE TEMPERATURE SETTING IN THE"
399 PRINT"HOME OF "A1$
400 OPEN1,0,0:INPUT#1,A3$:CLOSE1
```

```
401 IFA3$=""THEN400
402 GOSUB436
403 IFA1$="MS. LAWRENCE"ANDA3$="73"THEN411
404 IFA1$="MS. BROWN"ANDA3$="68"THEN411
405 IFA1$="MR. JONES"ANDA3$="63"THEN411
406 PRINT:PRINT"▒▒I'M SORRY, ";A3$;" IS NOT CORRECT"
407 FORP=1TO4500:NEXT
408 IFK=0THEN GOSUB449:K=1:GOTO397
409 PRINT:PRINT"▒▒ YOU NEED TO SEE MORE CLUES ▒"
410 FORP=1TO3000:NEXT:GOTO29
411 PRINT:PRINT"▒▒ THAT IS CORRECT! ▒":FORP=1TO1000:NEXT
412 IFPEEK(32975)=32THENPRINT"▒▒▒"TAB(27)A3$:GOTO415
413 IFPEEK(32915)=32THENPRINT"▒▒▒▒"TAB(27)A3$:GOTO415
414 IFPEEK(32955)=32THENPRINT"▒▒▒▒▒"TAB(27)A3$:GOTO415
415 GOSUB449
416 CC1=CC1+1
417 IFCC1<>3THENK=0:GOTO423
418 FORP=1TO2000:NEXT
419 PRINT"▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒YOU SOLVED THE PROBLEM!!!"
420 FORP=1TO3000:NEXT
421 W$="PROBLEM SOLVED"
422 GOTO323
423 PRINT"▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒WHAT IS THE NAME ";
424 PRINT"ANOTHER TEACHER"
425 GOTO428
426 PRINT"▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒";
427 PRINT"WHAT IS THE NAME OF ANOTHER TEACHER?"
428 GOTO360
429 A5$(CC1+1)=A1$
430 FORI=0TOCC1
431 IFA1$=A5$(I)THEN434
432 NEXTI
433 GOTO371
434 GOSUB454
435 GOTO423
436 A7$(CC1+1)=A3$
437 FORI=0TOCC1
438 IFA3$=A7$(I)THEN441
439 NEXTI
440 RETURN
441 GOSUB454
442 GOTO397
443 A8$(CC1+1)=A4$
444 FORI=0TOCC1
445 IFA4$=A8$(I)THEN448
446 NEXTI
447 RETURN
448 GOSUB454
449 PRINT"▒▒▒▒▒▒▒▒▒▒▒▒"
450 FORQ=1TO20
```

```
451 PRINT"                    ";
452 NEXTQ
453 RETURN
454 PRINT"▒▒BUT YOU ALREADY GAVE THAT ANSWER!"
455 FORP=1TO 2000:NEXT
456 GOTO449
457 PRINT"▒YOU ARE PART OF A RESEARCH PROJECT.":GOSUB493
458 PRINT "▒▒THIS GAME TODAY IS ONE OF THREE GAMES"
459 PRINT "YOU WILL BE ASKED TO SOLVE.":GOSUB494
460 PRINT "▒▒SOME OF YOU WILL BE WORKING ALONE"
461 PRINT "AND SOME OF YOU WILL BE WORKING WITH"
462 PRINT "OTHER STUDENTS TO SOLVE A PROBLEM ON"
463 PRINT "ON THIS MICROCOMPUTER.":GOSUB494
464 PRINT "▒▒THE COMPUTER WILL KEEP TRACK OF"
465 PRINT "HOW LONG IT TAKES YOU TO SOLVE THE "
466 PRINT "PROBLEM AND HOW MANY CLUES YOU ASK FOR."
467 GOSUB494
468 PRINT "▒GOOD LUCK!  HAVE FUN!"
469 PRINT "THANK YOU FOR VOLUNTEERING.":GOSUB 339
470 D1$="ENERGY AT HOME"
471 PRINT"▒▒▒▒HOW MANY ARE IN YOUR GROUP ";
472 OPEN1,0,0:INPUT#1,E$:IFE$=""THEN472
473 T1=VAL(E$):CLOSE1
474 PRINT:PRINT"▒▒WHAT IS THE DATE TODAY ";
475 OPEN1,0,0:INPUT#1,D2$:CLOSE1:IFD2$=""THEN475
476 FORI=1TOT1
477 PRINT"▒▒▒▒"
478 PRINT"▒▒STUDENT #";I
479 PRINT:PRINT"▒WHAT IS YOUR ID ";
480 OPEN1,0,0:INPUT#1,E$:CLOSE1:ID(I)=VAL(E$)
481 IFE$=""THEN480
482 PRINT:PRINT"▒WHAT IS YOUR GRADE ";
483 OPEN1,0,0:INPUT#1,E$:CLOSE1:G(I)=VAL(E$):IFE$=""THEN483
484 PRINT:PRINT"▒WHAT IS YOUR AGE ";
485 OPEN1,0,0:INPUT#1,E$:CLOSE1:E1(I)=VAL(E$):IFE$=""THEN485
486 PRINT:PRINT"▒WHAT IS YOUR SEX ";
487 OPEN1,0,0:INPUT#1,S$(I):CLOSE1:IFS$(I)=""THEN487
488 PRINT:PRINT"▒HOW MANY PROJECT GAMES HAVE YOU PLAYED ";
489 OPEN1,0,0:INPUT#1 E$:CLOSE1:B(I)=VAL(E$):IFE$=""THEN489
490 NEXTI
491 T2=TI
492 RETURN
493 FORP=1TO2500:NEXT:RETURN
494 FORP=1TO5000:NEXT:RETURN
495 FORP=1TO1500:NEXT:PRINT"▒"
496 OPEN11,1,1
497 PRINT#11,M
498 PRINT#11,D1$
499 PRINT#11,D2$
500 PRINT#11,T1
```

```
501 PRINT#11,W$
502 PRINT#11,T2
503 PRINT#11,T3
504 FORI=1TOT1
505 PRINT#11,ID(I)
506 PRINT#11,G(I)
507 PRINT#11,E1(I)
508 PRINT#11,S$(I)
509 PRINT#11,B(I)
510 NEXTI
511 FORI=1TOM
512 PRINT#11,Q$(I)
513 PRINT#11,Q(I)
514 NEXTI
515 FORI=0TO20
516 PRINT#11,A(I)
517 NEXTI
518 CLOSE11
519 END
```

# APPENDIX D

## List of Problem and Clues for Microcomputer Program "Global Travelers"

## LIST OF PROBLEM AND CLUES FOR MICROCOMPUTER PROGRAM "GLOBAL TRAVELERS"

### The Problem

Three U.S. citizens took a trip.

Your task is to match each traveler's name with the city they visited and the airlines they used.

### The Clues

#1 Bob traveled further than all the other travelers.

#2 The Braniff passenger exchanged dollars for pesos before leaving the airport.

#3 All travelers visited capitol cities.

#4 Joan visited a very modern city.

#5 All the travelers are from the same city in midwestern U.S.A.

#6 Some of the souvenirs that Pat looked at were inscribed 'Made in Japan'.

#7 The TWA passenger visited the Great Wall of China, the only man-made structure on the earth that is visible from the moon.

#8 Joan took a short side trip to climb the most famous pyramids in the western hemisphere.

#9 Joan thought she could get a lot of bargains because the currency exchange rate has doubled recently.

#10 Two of the travelers are men.

#11 The Air France passenger could see the Eiffel Tower as they were landing.

#12 Peking is one of the oldest cities in northern China.

#13 Sam bought several pieces of Limoges China as a surprise for his wife.

#14 Most of the people in China wear the same kind of clothes, loose fitting pants and jacket.

#15 Bob had not learned the local language because it had not been offered in his high school.

#16 The visitor to this capitol city bought a sombrero to keep cool in the very hot mornings.

#17 In the city that Bob visited most everyone was dressed alike.

#18 Sam especially enjoyed walking through the famous Hall of Mirrors in the Versailles Palace outside Paris.

#19 The Ming vase was over 600 years old so its new owner would have to pay a duty tax in this ancient country.

#20 Sam could converse with the people he met because he had studied their language for 3 years in high school.

```
1 REM ** PET BASIC: GLOBAL TRAVELERS;
2 REM ** A LOGICAL REASONING GAME.
3 REM ** COPYRIGHT (C) 1979 BY
4 REM ** DOROTHY A. COX & JAMES M. COX
5 DIMA(20),Q(75),Q$(75)
6 FORI=1TO9:A5$(I)="":NEXT
7 FORI=1TO9:A6$(I)="":NEXT
8 FORI=1TO9:A7$(I)="":NEXT
9 FORI=1TO9:A8$(I)="":NEXT
10 GOSUB452:GOSUB238
11 PRINT"▒▒▒▒▒THREE U.S. CITIZENS TOOK A TRIP."
12 PRINT"▒▒▒▒YOUR TASK IS TO MATCH"
13 PRINT"▒  EACH TRAVELER'S NAME WITH"
14 PRINT"  THE CITY THEY VISITED, AND"
15 PRINT"  THE AIRLINES THEY USED."
16 GOSUB329
17 PRINT"▒▒▒THERE ARE 20 CLUES. YOU MAY ASK FOR"
18 PRINT"THEM BY CATEGORY OR BY NUMBER AS MANY"
19 PRINT"TIMES AS YOU WISH."
20 PRINT"▒▒WHEN YOU CALL FOR A CLUE THE CLUE NUMBER"
21 PRINT"WILL CHANGE COLOR"
22 PRINT"▒▒▒WHEN YOU THINK YOU HAVE THE SOLUTION,"
23 PRINT"CALL FOR CLUE # -2."
24 PRINT"▒WHEN YOU WANT TO GIVE UP, CALL FOR "
25 PRINT"CLUE # -1."
26 GOSUB329
27 PRINT"▒▒▒REMEMBER:▒YOUR TASK IS TO MATCH"
28 PRINT"EACH TRAVELER'S NAME WITH"
29 PRINT"THE CITY THEY VISITED, AND"
30 PRINT"THE AIRLINES THEY USED."
31 PRINT"▒▒▒▒▒▒▒▒GOT THE SOLUTION?'-2'▒;  ▒GIVE UP? '-1' "
32 GOSUB216
33 OPEN1,0,0:INPUT#1,A$:CLOSE1
34 X=VAL(A$):IFX=0THENPRINT"▒▒▒  ▒▒▒";:GOTO33
35 IFX=-1THENQ(M)=-1:GOTO306
36 IFX=-2THENQ(M)=-2:GOTO340
37 IFX>20THEN212
38 IFX<0ORX>20THEN233
39 IFINT(X)<>XTHEN233
40 IFX>10THENX=X-10:GOTO42
41 ONXGOTO43,51,60,67,74,82,90,100,109,118
42 ONXGOTO125,133,141,149,158,167,176,184,194,203
43 PRINT"▒▒▒▒▒▒▒▒▒▒▒▒CLUE # 1                    ▒"
44 PRINT"BOB TRAVELED FARTHER THAN ALL THE "
45 PRINT"OTHER TRAVELERS."
46 Q(M)=1
47 IFPEEK(33648)=177THENPOKE33648,49:GOTO49
48 POKE33648,177
49 A(1)=A(1)+1
50 GOTO232
```

```
51 PRINT"SQQQQQQQQQQQCLUE # 2                             ]"
52 PRINT"THE BRANIFF PASSENGER EXCHANGED "
53 PRINT"DOLLARS FOR PESOS BEFORE LEAVING"
54 PRINT"THE AIRPORT."
55 Q(M)=2
56 IFPEEK(33651)=178THENPOKE33651,50:GOTO58
57 POKE33651,178
58 A(2)=A(2)+1
59 GOTO232
60 PRINT"SQQQQQQQQQQQCLUE # 3                             ]"
61 PRINT"ALL TRAVELERS VISITED CAPITOL CITIES."
62 Q(M)=3
63 IFPEEK(33654)=179THENPOKE33654,51:GOTO65
64 POKE33654,179
65 A(3)=A(3)+1
66 GOTO232
67 PRINT"SQQQQQQQQQQQCLUE # 4                             ]"
68 PRINT"JOAN VISITED A VERY MODERN CITY."
69 Q(M)=4
70 IFPEEK(33657)=180THENPOKE33657,52:GOTO72
71 POKE33657,180
72 A(4)=A(4)+1
73 GOTO232
74 PRINT"SQQQQQQQQQQQCLUE # 5                             ]"
75 PRINT"ALL THE TRAVELERS ARE FROM THE SAME"
76 PRINT"CITY IN MIDWESTERN U.S.A."
77 Q(M)=5
78 IFPEEK(33660)=181THENPOKE33660,53:GOTO80
79 POKE33660,181
80 A(5)=A(5)+1
81 GOTO232
82 PRINT"SQQQQQQQQQQQCLUE # 6                             ]"
83 PRINT"SOME OF THE SOUVENIRS THAT PAT LOOKED"
84 PRINT"AT WERE INSCRIBED 'MADE IN JAPAN'."
85 Q(M)=6
86 IFPEEK(33663)=182THENPOKE33663,54:GOTO88
87 POKE33663,182
88 A(6)=A(6)+1
89 GOTO232
90 PRINT"SQQQQQQQQQQQCLUE # 7                             ]"
91 PRINT"THE TWA PASSENGER VISITED THE"
92 PRINT"GREAT WALL OF CHINA, THE ONLY"
93 PRINT"MAN-MADE STRUCTURE ON THE EARTH"
94 PRINT"THAT IS VISIBLE FROM THE MOON."
95 Q(M)=7
96 IFPEEK(33666)=183THENPOKE33666,55:GOTO98
97 POKE33666,183
98 A(7)=A(7)+1
99 GOTO232
100 PRINT"SQQQQQQQQQQQCLUE # 8                             ]"
```

```
101 PRINT"JOAN TOOK A SHORT SIDE TRIP TO"
102 PRINT"CLIMB THE MOST FAMOUS PYRAMIDS"
103 PRINT"IN THE WESTERN HEMISPHERE."
104 Q(M)=8
105 IFPEEK(33669)=184THENPOKE33669,56:GOTO107
106 POKE33669,184
107 A(8)=A(8)+1
108 GOTO232
109 PRINT"SQQQQQQQQQCLUE # 9                         N"
110 PRINT"JOAN THOUGHT SHE COULD GET A LOT OF "
111 PRINT"BARGAINS BECAUSE THE CURRENCY EXCHANGE"
112 PRINT"RATE HAS DOUBLED RECENTLY."
113 Q(M)=9
114 IFPEEK(33672)=185THENPOKE33672,57:GOTO116
115 POKE33672,185
116 A(9)=A(9)+1
117 GOTO232
118 PRINT"SQQQQQQQQQCLUE # 10                        N"
119 PRINT"2 OF THE TRAVELERS ARE MEN."
120 Q(M)=10
121 IFPEEK(33675)=177THENPOKE33675,49:POKE33676,48:GOTO123
122 POKE33675,177:POKE33676,176
123 A(10)=A(10)+1
124 GOTO232
125 PRINT"SQQQQQQQQQCLUE # 11                        N"
126 PRINT"THE AIR FRANCE PASSENGER COULD SEE "
127 PRINT"THE EIFFEL TOWER AS THEY WERE LANDING."
128 Q(M)=11
129 IFPEEK(33689)=177THENPOKE33689,49:POKE33690,49:GOTO131
130 POKE33689,177:POKE33690,177
131 A(11)=A(11)+1
132 GOTO232
133 PRINT"SQQQQQQQQQCLUE # 12                        N"
134 PRINT"PEKING IS ONE OF THE OLDEST CITIES"
135 PRINT"IN NORTHERN CHINA."
136 Q(M)=12
137 IFPEEK(33692)=177THENPOKE33692,49:POKE33693,50:GOTO139
138 POKE33692,177:POKE33693,178
139 A(12)=A(12)+1
140 GOTO232
141 PRINT"SQQQQQQQQQCLUE # 13                        N"
142 PRINT"SAM BOUGHT SEVERAL PIECES OF LIMOGES"
143 PRINT"CHINA AS A SURPRISE FOR HIS WIFE."
144 Q(M)=13
145 IFPEEK(33695)=177THENPOKE33695,49:POKE33696,51:GOTO147
146 POKE33695,177:POKE33696,179
147 A(13)=A(13)+1
148 GOTO232
149 PRINT"SQQQQQQQQQCLUE # 14                        N"
150 PRINT"MOST OF THE PEOPLE IN CHINA"
```

```
151 PRINT"WEAR THE SAME KIND OF CLOTHES,"
152 PRINT"LOOSE FITTING PANTS AND JACKET."
153 Q(M)=14
154 IFPEEK(33698)=177THENPOKE33698,49:POKE33699,52:GOTO156
155 POKE33698,177:POKE33699,180
156 A(14)=A(14)+1
157 GOTO232
158 PRINT"▒▒▒▒▒▒▒▒▒▒▒CLUE # 15                   ▒"
159 PRINT"BOB HAD NOT LEARNED THE LOCAL LANGUAGE"
160 PRINT"BECAUSE IT HAD NOT BEEN OFFERED"
161 PRINT"IN HIS HIGH SCHOOL."
162 Q(M)=15
163 IFPEEK(33701)=177THENPOKE33701,49:POKE33702,53:GOTO165
164 POKE33701,177:POKE33702,181
165 A(15)=A(15)+1
166 GOTO232
167 PRINT"▒▒▒▒▒▒▒▒▒▒▒CLUE # 16                   ▒"
168 PRINT"THE VISITOR TO THIS CAPITOL CITY "
169 PRINT"BOUGHT A SOMBRERO▮TO KEEP COOL IN "
170 PRINT"THE VERY HOT MORNINGS."
171 Q(M)=16
172 IFPEEK(33704)=177THENPOKE33704,49:POKE33705,54:GOTO174
173 POKE33704,177:POKE33705,182
174 A(16)=A(16)+1
175 GOTO232
176 PRINT"▒▒▒▒▒▒▒▒▒▒▒CLUE # 17                   ▒"
177 PRINT"IN THE CITY THAT BOB VISITED MOST"
178 PRINT"EVERYONE WAS DRESSED ALIKE."
179 Q(M)=17
180 IFPEEK(33707)=177THENPOKE33707,49:POKE33708,55:GOTO182
181 POKE33707,177:POKE33708,183
182 A(17)=A(17)+1
183 GOTO232
184 PRINT"▒▒▒▒▒▒▒▒▒▒▒CLUE # 18                   ▒"
185 PRINT"SAM ESPECIALLY ENJOYED WALKING"
186 PRINT"THROUGH THE FAMOUS HALL OF MIRRORS"
187 PRINT "IN THE VERSAILLES PALACE OUTSIDE"
188 PRINT"PARIS."
189 Q(M)=18
190 IFPEEK(33710)=177THENPOKE33710,49:POKE33711,56:GOTO192
191 POKE33710,177:POKE33711,184
192 A(18)=A(18)+1
193 GOTO232
194 PRINT"▒▒▒▒▒▒▒▒▒▒▒CLUE # 19                   ▒"
195 PRINT"THE MING VASE WAS OVER 600 YEARS OLD"
196 PRINT"SO ITS NEW OWNER WOULD HAVE TO PAY A"
197 PRINT"DUTY TAX IN THIS ANCIENT COUNTRY."
198 Q(M)=19
199 IFPEEK(33713)=177THENPOKE33713,49:POKE33714,57:GOTO201
200 POKE33713,177:POKE33714,185
```

```
201 A(19)=A(19)+1
202 GOTO232
203 PRINT"▒▒▒▒▒▒▒▒▒▒▒▒CLUE # 20                              ▒"
204 PRINT"SAM COULD CONVERSE WITH THE PEOPLE"
205 PRINT"HE MET BECAUSE HE HAD STUDIED THEIR"
206 PRINT"LANGUAGE FOR 3 YEARS IN HIGH SCHOOL."
207 Q(M)=20
208 IFPEEK(33716)=178THENPOKE33716,50:POKE33717,48:GOTO210
209 POKE33716,178:POKE33717,176
210 A(20)=A(20)+1
211 GOTO232
212 PRINT"▒▒▒▒▒▒▒▒▒▒▒▒                            "
213 PRINT"▒THERE ARE ONLY 20 CLUES"
214 Q(M)=X
215 GOTO232
216 J=177
217 FORN=33648TO33672STEP3
218 POKEN,J
219 J=J+1
220 NEXTN
221 POKE33675,177
222 POKE33676,176
223 J=177
224 FORN=33689TO33713STEP3
225 POKEN,177
226 POKEN+1,J
227 J=J+1
228 NEXTN
229 POKE33716,178
230 POKE33717,176
231 GOTO233
232 GOSUB329
233 PRINT"▒▒▒▒▒▒▒▒▒"
234 FORI=1TO12
235 PRINT"                                        "
236 NEXTI
237 PRINT"▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒
238 PRINT"▒▒▒▒▒▒▒▒▒▒WHAT KIND OF CLUE DO YOU WANT:▒":M=M+1
239 PRINT"ABOUT A SIDE TRIP?      TYPE 'T'"
240 PRINT"ABOUT THE CITIES?       TYPE 'C'"
241 PRINT"ABOUT THE LANGUAGE?     TYPE 'L'"
242 PRINT"ABOUT THE AIRLINE?      TYPE 'A'"
243 PRINT"BY THE CLUE NUMBER?     TYPE 'N'";
244 GETA$:IFA$=""THEN244
245 Q$(M)=A$
246 IFA$="T"THEN252
247 IFA$="C"THEN266
248 IFA$="A"THEN259
249 IFA$="L"THEN273
250 IFA$="N"THEN280
```

```
251 GOTO244
252 PRINT"█████████"
253 FORI=1TO10
254 PRINT"                                       "
255 NEXTI
256 Z0=Z0+1
257 IFZ0=4THENZ0=1
258 ONZ0GOTO184,100,90
259 PRINT"█████████"
260 FORI=1TO10
261 PRINT"                                       "
262 NEXTI
263 Z0=Z0+1
264 IFZ0=4THENZ0=1
265 ONZ0GOTO90,51,125
266 PRINT"█████████"
267 FORI=1TO10
268 PRINT"                                       "
269 NEXTI
270 Z1=Z1+1
271 IFZ1=8THENZ1=1
272 ONZ1GOTO74,184,133,67,176,60,167
273 PRINT"█████████"
274 FORI=1TO10
275 PRINT"                                       "
276 NEXTI
277 Z3=Z3+1
278 IFZ3=3THENZ3=1
279 ONZ3GOTO158,203
280 PRINT"███████████████████████████";
281 PRINT"█ PRESS RETURN TO CONTINUE █"
282 PRINT"████████"
283 FORI=1TO14
284 PRINT"                                       "
285 NEXTI
286 PRINT"██████████████WHAT CLUE WOULD YOU LIKE? ";
287 GOTO33
288 PRINT"█"
289 A=32768:B=A:C=33767:D=C:E=127
290 FORI=1TO39
291 POKEA,E:POKEB,E:POKEC,E:POKED,E
292 IFI<25THENA=A+1:B=B+40:C=C-1:D=D-40
293 IFI>24THENA=A+1:C=C-1
294 NEXTI
295 PRINTTAB(11)"███GLOBAL TRAVELERS"
296 PRINT"████████████THIS IS AN EXERCISE IN"
297 PRINT"██████████LOGIC AND REASONING."
298 PRINT"█████████WRITTEN BY    DOROTHY A. COX"
299 PRINT"███████PROGRAMMED BY   JAMES M. COX"
300 GOSUB329
```

```
301 RETURN
302 FORN=1TO20
303 A(N)=0
304 NEXTN
305 RETURN
306 W$="GAVE UP"
307 PRINT"]QQQQ NAME    |   CITY        |  AIRLINE"
308 PRINT"————————+————————————+——————————— "
309 PRINT"        |            |            "
310 PRINT" BOB    | PEKING     | TWA    "
311 PRINT" JOAN   | MEX. CITY  | BRANIFF "
312 PRINT" SAM    | PARIS      | AIR FRANCE"
313 GOSUB329
314 PRINT"]"
315 FORL=1TO20:A(0)=A(0)+A(L):NEXTL
316 PRINT"]QQQYOU CALLED FOR ";A(0);" CLUES"
317 GOSUB329
318 PRINT"]"
319 FORK=1TO20
320 PRINT"YOU CALLED FOR CLUE #";
321 IFK<10THENPRINT" ";
322 PRINTK;A(K);"TIME(S)"
323 NEXTK
324 GOSUB329
325 T3=TI
326 PRINT"]QQQTHANK YOU FOR PARTICIPATING IN THIS "
327 PRINT"PROJECT."
328 GOTO489
329 B$=" ]"
330 A$=" PRESS RETURN TO CONTINUE "
331 PRINT"SQQQQQQQQQQQQQQQQQQQQQQ████";A$
332 GETC$:IFC$=""THEN339
333 IFC$<>CHR$(13)THEN332
334 PRINT"SQQQQQQQQQQQQQQQQQQQQQQ████
335 RETURN
336 A$=B$+A$:GOTO331
337 C=C+1:IFC=INT(C/2)*2THEN336
338 GOTO330
339 FORP=1TO250:NEXT:GOTO337
340 CC1=0
341 PRINT"]QQQQ NAME    |   CITY        |  AIRLINE "
342 PRINT"————————+————————————+———————————  "
343 PRINT"        |            |          "
344 PRINT"        |            |          "
345 PRINT"        |            |          "
346 PRINT"        |            |          "
347 PRINT"SQQQQQQQQQQQQQQ";
348 K=0
349 PRINT"WHAT IS THE NAME OF A TRAVELER?"
350 OPEN1,0,0:INPUT#1,A1$:CLOSE1
```

```
351 IFA1$=""THEN350
352 IFA1$="BOB" OR A1$="JOAN" OR A1$="SAM"THEN359
353 PRINT:PRINT"▒▒I'M SORRY, ";A1$;" IS NOT CORRECT"
354 IFK=0ANDCC1=0THEN PRINT"▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒";
355 K=1:GOTO349
356 IFK=0ANDCC1<>0THEN K=1:GOTO413
357 PRINT:PRINT"▒▒ YOU NEED TO SEE MORE CLUES ▒"
358 FORP=1TO3000:NEXT:GOTO27
359 GOSUB416
360 PRINT:PRINT"▒▒ THAT IS CORRECT! ▒":FORP=1TO1000:NEXT
361 IFPEEK(33049)=32THENPRINT"▒▒▒▒▒▒▒▒▒▒";A1$:GOTO364
362 IFPEEK(33089)=32THENPRINT"▒▒▒▒▒▒▒▒▒▒▒";A1$:GOTO364
363 IFPEEK(33129)=32THENPRINT"▒▒▒▒▒▒▒▒▒▒▒▒";A1$:GOTO364
364 GOSUB444
365 K=0
366 PRINT"▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒"
367 PRINT"WHAT CAPITOL CITY DID "A1$" VISIT?"
368 OPEN1,0,0:INPUT#1,A2$:CLOSE1
369 IFA2$=""THEN368
370 GOSUB423
371 IFA2$="MEXICO CITY"THENA2$="MEX. CITY"
372 IFA1$="BOB"ANDA2$="PEKING"THEN379
373 IFA1$="JOAN"ANDA2$="MEX. CITY"THEN379
374 IFA1$="SAM"ANDA2$="PARIS"THEN379
375 PRINT:PRINT"▒▒I'M SORRY, ";A2$;" IS NOT CORRECT"
376 IFK=0THENPRINT"▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒":K=1:GOTO367
377 PRINT:PRINT"▒▒ YOU NEED TO SEE MORE CLUES ▒"
378 FORP=1TO3000:NEXT:GOTO27
379 PRINT:PRINT"▒▒ THAT IS CORRECT! ▒":FORP=1TO1000:NEXT
380 IFPEEK(33058)=32THENPRINT"▒▒▒▒▒▒▒▒▒"TAB(10)A2$:GOTO383
381 IFPEEK(33098)=32THENPRINT"▒▒▒▒▒▒▒▒▒▒"TAB(10)A2$:GOTO383
382 IFPEEK(33138)=32THENPRINT"▒▒▒▒▒▒▒▒▒▒▒"TAB(10)A2$:GOTO383
383 GOSUB444:K=0
384 PRINT"▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒"
385 PRINT"WHAT AIRLINE DID ";A1$;" TRAVEL ON?"
386 OPEN1,0,0:INPUT#1,A3$:CLOSE1
387 IFA3$=""THEN386
388 GOSUB430
389 IFA1$="BOB"ANDA3$="TWA"THEN396
390 IFA1$="JOAN"ANDA3$="BRANIFF"THEN396
391 IFA1$="SAM"ANDA3$="AIR FRANCE"THEN396
392 PRINT:PRINT"▒▒I'M SORRY, ";A3$;" IS NOT CORRECT"
393 IFK=0THEN PRINT"▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒":K=1:GOTO385
394 PRINT:PRINT"▒▒ YOU NEED TO SEE MORE CLUES ▒"
395 FORP=1TO3000:NEXT:GOTO27
396 PRINT:PRINT"▒▒ THAT IS CORRECT! ▒":FORP=1TO1000:NEXT
397 IFPEEK(33071)=32THENPRINT"▒▒▒▒▒▒▒▒▒"TAB(23)A3$:GOTO401
398 IFPEEK(33111)=32THENPRINT"▒▒▒▒▒▒▒▒▒▒"TAB(23)A3$:GOTO401
399 IFPEEK(33151)=32THENPRINT"▒▒▒▒▒▒▒▒▒▒▒"TAB(23)A3$:GOTO401
400 IFPEEK(33187)=32THENPRINT"▒▒▒▒▒▒▒▒▒▒▒▒"TAB(23)A3$
```

```
401 GOSUB444:K=0
402 GOSUB444
403 CC1=CC1+1
404 IFCC1<>3THENK=0:GOTO410
405 FORP=1TO2000:NEXT
406 PRINT"[illegible]YOU SOLVED THE PROBLEM!!!"
407 FORP=1TO3000:NEXT
408 W$="PROBLEM SOLVED"
409 GOTO314
410 PRINT"[illegible]WHAT IS THE NAME OF ";
411 PRINT"ANOTHER TRAVELER?"
412 GOTO415
413 PRINT"[illegible]WHAT IS THE NAME OF ";
414 PRINT"ANOTHER TRAVELER?"
415 GOTO350
416 A5$(CC1+1)=A1$
417 FORI=0TOCC1
418 IFA1$=A5$(I)THEN421
419 NEXTI
420 RETURN
421 GOSUB449
422 GOTO410
423 A6$(CC1+1)=A2$
424 FORI=0TOCC1
425 IFA2$=A6$(I)THEN428
426 NEXTI
427 RETURN
428 GOSUB449
429 GOTO366
430 A7$(CC1+1)=A3$
431 FORI=0TOCC1
432 IFA3$=A7$(I)THEN435
433 NEXTI
434 RETURN
435 GOSUB449
436 GOTO384
437 A8$(CC1+1)=A4$
438 FORI=0TOCC1
439 IFA4$=A8$(I)THEN442
440 NEXTI
441 RETURN
442 GOSUB449
443 GOTO63999
444 PRINT"[illegible]"
445 FORQ=1TO12
446 PRINT"                                        "
447 NEXTQ
448 RETURN
449 PRINT"[illegible]BUT YOU ALREADY GAVE THAT ANSWER!"
450 FORP=1TO 2000:NEXT
```

```
451 GOTO444
452 PRINT"]YOU ARE PART OF A RESEARCH PROJECT.":GOSUB486
453 PRINT "▒▒THIS GAME TODAY IS ONE OF THREE GAMES"
454 PRINT "YOU WILL BE ASKED TO SOLVE.":GOSUB487
455 PRINT "▒▒SOME OF YOU WILL BE WORKING ALONE"
456 PRINT "AND SOME OF YOU WILL BE WORKING WITH"
457 PRINT "OTHER STUDENTS TO SOLVE A PROBLEM ON"
458 PRINT "ON THIS MICROCOMPUTER.":GOSUB487
459 PRINT "▒▒THE COMPUTER WILL KEEP TRACK OF"
460 PRINT "HOW LONG IT TAKES YOU TO SOLVE THE "
461 PRINT "PROBLEM AND HOW MANY CLUES YOU ASK FOR.":GOSUB487
462 PRINT "▒GOOD LUCK!  HAVE FUN!"
463 PRINT "THANK YOU FOR VOLUNTEERING.":GOSUB 329
464 D1$="GLOBAL TRAVELERS"
465 PRINT"]▒▒▒▒▒▒HOW MANY ARE IN YOUR GROUP ";
466 OPEN1,0,0:INPUT#1,E$:IFE$=""THEN466
467 T1=VAL(E$):CLOSE1
468 PRINT:PRINT"▒▒WHAT IS THE DATE TODAY ";
469 OPEN1,0,0:INPUT#1,D2$:CLOSE1:IFD2$=""THEN469
470 FORI=1TOT1
471 PRINT"]▒▒▒▒"
472 PRINT"▒▒STUDENT #";I
473 PRINT:PRINT"▒WHAT IS YOUR ID ";
474 OPEN1,0,0:INPUT#1,E$:CLOSE1:ID(I)=VAL(E$):IFE$=""THEN474
475 PRINT:PRINT"▒WHAT IS YOUR GRADE ";
476 OPEN1,0,0:INPUT#1,E$:CLOSE1:G(I)=VAL(E$):IFE$=""THEN476
477 PRINT:PRINT"▒WHAT IS YOUR AGE ";
478 OPEN1,0,0:INPUT#1,E$:CLOSE1:E1(I)=VAL(E$):IFE$=""THEN478
479 PRINT:PRINT"▒WHAT IS YOUR SEX ";
480 OPEN1,0,0:INPUT#1,S$(I):CLOSE1:IFS$(I)=""THEN480
481 PRINT:PRINT"▒HOW MANY PROJECT GAMES HAVE YOU PLAYED ";
482 OPEN1,0,0:INPUT#1,E$:CLOSE1:B(I)=VAL(E$):IFE$=""THEN482
483 NEXTI
484 T2=TI
485 RETURN
486 FORP=1TO2500:NEXT:RETURN
487 FORP=1TO5000:NEXT:RETURN
488 FORP=1TO1500:NEXT:PRINT"]"
489 OPEN11,1,1
490 PRINT#11,M
491 PRINT#11,D1$
492 PRINT#11,D2$
493 PRINT#11,T1
494 PRINT#11,W$
495 PRINT#11,T2
496 PRINT#11,T3
497 FORI=1TOT1
498 PRINT#11,ID(I)
499 PRINT#11,G(I)
500 PRINT#11,E1(I)
```

```
501 PRINT#11,S$(I)
502 PRINT#11,B(I)
503 NEXTI
504 FORI=1TOM
505 PRINT#11,Q$(I)
506 PRINT#11,Q(I)
507 NEXTI
508 FORI=0TO20
509 PRINT#11,A(I)
510 NEXTI
511 CLOSE11
```

# APPENDIX E

## Microcomputer Program Listing for "Data Retrieval"

```
0 REM *** PET BASIC: DATA RETRIEVAL:
1 REM *** FOR RESEARCH PROGRAMS;
2 REM *** "VERTEBRATE PETS",
3 REM *** "GLOBAL TRAVELERS", AND
4 REM *** "ENERGY AT HOME".
5 REM ***
6 REM *** COPYRIGHT (C) 1979 BY
7 REM *** JAMES M. COX
8 REM *******************************
9 DIMA1$(150),C(150),D(21)
10 PRINT"♥▓▓▓DATA RETRIEVAL▓▓▓"
11 OPEN11,1,0
12 INPUT#11,G$
13 INPUT#11,N
14 INPUT#11,D$
15 FORI=1TON
16 INPUT#11,ID(I)
17 INPUT#11,G(I)
18 INPUT#11,A(I)
19 INPUT#11,S$(I)
20 INPUT#11,B(I)
21 NEXTI
22 INPUT#11,B
23 FORI=1TO150
24 INPUT#11,A1$(I)
25 INPUT#11,C(I)
26 IFC(I)=-1ORC(I)=0THEN28
27 NEXTI
28 INPUT#11,E$
29 INPUT#11,T
30 A=20
31 IFG$<>"VERTEBRATE PETS"THENA=21
32 FORI=1TOA
33 INPUT#11,D(I)
34 NEXTI
35 INPUT#11,E
36 CLOSE11
37 PRINT"♥▓▓▓"G$
38 PRINT"▓NUMBER IN GROUP";N
39 PRINT"▓DATE  ";D$
40 Y=INT(((E-B)/3600)+.5)
41 PRINT"▓TOTAL TIME "Y" MINUTES"
42 GOSUB77
43 PRINT"♥▓▓▓STUDENT #  ";1
44 PRINT"▓ID          ";ID(1)
45 PRINT"▓GRADE       ";G(1)
46 PRINT"▓AGE         ";A(1)
47 PRINT"▓SEX          ";S$(1)
48 PRINT"▓# OF GAMES ";B(1)
49 FORI=1TO(N-1)
50 Z=15+I+3*(I-1)-1
```

```
51 PRINT"SQQQ";TAB(Z);I+1
52 PRINT"Q";TAB(Z);ID(I+1)
53 PRINT"Q";TAB(Z);G(I+1)
54 PRINT"Q";TAB(Z);A(I+1)
55 PRINT"Q";TAB(Z+1);S$(I+1)
56 PRINT"Q";TAB(Z);B(I+1)
57 NEXTI
58 GOSUB77
59 PRINT"♥TYPE OF CLUE        CLUE NUMBER"
60 FORI=1TOT
61 PRINTTAB(3)A1$(I),,C(I)
62 IFI=15ORI=30ORI=45ORI=60ORI=75ORI=90THENGOSUB77
63 NEXTI
64 PRINT"QQ"E$
65 PRINT"QTOTAL # OF CLUES "T
66 GOSUB77
67 PRINT"♥"
68 A=20
69 IFG$<>"VERTEBRATE PETS"THENA=21
70 FORI=1TOA
71 PRINT"CALLED FOR CLUE # ";
72 IFI<10THENPRINT" ";
73 PRINTI;D(I);" TIMES"
74 NEXTI
75 GOSUB77
76 END
77 B$="R"
78 A$="PRESS RETURN TO CONTINUE"
79 PRINT"SQQQQQQQQQQQQQQQQQQQQQQ]]]]]]]]";A$
80 GETC$:IFC$=""THEN85
81 PRINT"♥":RETURN
82 A$=B$+A$:GOTO79
83 C=C+1:IFC=INT(C/2)*2THEN82
84 GOTO78
85 FORP=1TO250:NEXT:GOTO83
```

# APPENDIX F

## Microcomputer Program Listing for "Try a Matrix"

```
0 REM *** PET BASIC: TRY A MATRIX
1 REM *** A TRAINING PROGRAM FOR
2 REM *** HELPING STUDENTS TO
3 REM *** ORGANIZE DATA.
4 REM *** COPYRIGHT (C) 1979 BY
5 REM *** DOROTHY A. COX & JAMES M. COX
6 REM ********************************
7 PRINT"▒▒▒▒▒"TAB(12)"TRY A ▚MATRIX▀"
8 GOSUB193
9 PRINT"▒▒  WHEN YOU HAVE A COMPLICATED PROBLEM"
10 PRINT"▒  TO SOLVE WITH MANY FACTS, SOMETIMES"
11 PRINT"▒  IT CAN HELP TO USE A ▚MATRIX.▀"
12 GOSUB193
13 A=33380
14 FORI=1TO4
15 POKEA,24
16 FORP=1TO250:NEXT
17 A=A+4
18 C=C+1
19 NEXTI
20 IFC=4THENA=33420:GOTO14
21 IFC=8THENA=33460:GOTO14
22 IFC=12THENA=33500:GOTO14
23 GOSUB195
24 GOSUB201
25 PRINT"▒▒▒▒  A ▚MATRIX▀ CAN HELP YOU TO ORGANIZE"
26 PRINT"▒  YOUR FACTS INTO A CHART SO THAT YOU"
27 PRINT"▒  CAN SEE ▚IF▀ THE FACTS RELATE TO EACH"
28 PRINT"▒  OTHER AND ▚HOW.▀"
29 GOSUB193
30 GOSUB201
31 PRINT"▒EXAMPLE:"
32 PRINT"▒EVERYTIME YOU USE A MULTIPLICATION"
33 PRINT"▒TABLE, YOU ARE USING A ▚MATRIX▀ OF"
34 PRINT"▒FACTS THAT RELATE TO EACH OTHER."
35 GOSUB193
36 PRINT"▒▒▒X | 1   2   3   4   5   6   7   8 ...
37 PRINT"──┼──────────────────────────────────────
38 PRINT"1 | 1   2   3   4   5   6   7   8
39 PRINT"  |
40 PRINT"2 | 2   4   6   8  10  12  14  16
41 PRINT"  |
42 PRINT"3 | 3   6   9  12  15  18  21  24
43 PRINT"  |
44 PRINT". |
45 PRINT".         AND SO ON ..."
46 PRINT".
47 GOSUB193
48 GOSUB201
49 PRINT"▒LETS BUILD A ▚MATRIX▀"
50 PRINT"▒▒SUPPOSE YOUR PROBLEM IS TO NAME SOME"
```

```
51 PRINT"▒DRIVERS, THE KIND OF CAR THEY DRIVE"
52 PRINT"▒AND THE COLOR OF EACH CAR."
53 GOSUB193
54 PRINT"▒▒AS YOU LOOK AT YOUR PROBLEM, YOU SEE"
55 PRINT"▒THAT THREE KINDS OF INFORMATION ARE"
56 PRINT"▒NEEDED.";
57 GOSUB193
58 PRINT"    ▚ DRIVERS NAME ■"
59 GOSUB195
60 PRINTTAB(11)"▒▚ KIND OF CAR  ■"
61 GOSUB195
62 PRINTTAB(11)"▒▚ COLOR OF CAR ■"
63 GOSUB195
64 GOSUB201
65 PRINT"▛▚ REMEMBER ■"
66 PRINT"YOUR PROBLEM IS TO NAME SOME DRIVERS,"
67 PRINT"THE KIND OF CAR THEY DRIVE, AND THE"
68 PRINT"COLOR OF EACH CAR."
69 GOSUB193
70 PRINT"▒▒YOU WOULD START BY SETTING UP A"
71 PRINT"▒▚MATRIX■ OF THREE COLUMNS, ONE FOR"
72 PRINT"▒EACH KIND OF ANSWER."
73 GOSUB193
74 PRINT"▒   | DRIVER |   CAR   |  COLOR |"
75 PRINT"   ├────────┼─────────┼────────┤"
76 PRINT"   │        │         │        │"
77 PRINT"   │        │         │        │"
78 GOSUB193
79 PRINT"▒BY DOING THIS YOU CAN SEE HOW YOUR"
80 PRINT"▒INFORMATION FITS TOGETHER."
81 GOSUB193
82 GOSUB201
83 PRINT"▙▒▒▒▒"
84 GOSUB211
85 PRINT"▙▒▒▒▒▒   | DRIVER |   CAR   |  COLOR |"
86 PRINT"   ├────────┼─────────┼────────┤"
87 PRINT"   │        │         │        │"
88 PRINT"   │        │         │        │"
89 PRINT"   │        │         │        │"
90 PRINT"   │        │         │        │"
91 PRINT"   │        │         │        │"
92 GOSUB195
93 PRINT"▒▒AS YOU BEGIN TO FIND NAMES IN THE"
94 PRINT"▒CLUES, YOU CAN FILL THEM IN."
95 GOSUB193
96 PRINT"▒ONE CLUE SAYS THAT BILL IS A DRIVER."
97 PRINT"▒TYPE HIS NAME IN THE MATRIX."
98 PRINT"▙▒▒▒▒▒▒▒████";
99 INPUTA$
100 POKE33052,32
```

```
101 GOSUB197
102 PRINT"▒▒▒▒▒▒▒▒▒▒▒▒":GOSUB215
103 PRINT"▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒ANOTHER DRIVER'S NAME IS SUE."
104 PRINT"▒TYPE HER NAME IN THE MATRIX."
105 PRINT"▒▒▒▒▒▒▒▒▒▒▒▒████";
106 INPUTA$
107 POKE33092,32
108 GOSUB197
109 PRINT"▒▒▒▒▒▒▒▒▒▒▒▒":GOSUB215
110 PRINT"▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒ANOTHER DRIVER'S NAME IS PATTI."
111 PRINT"▒TYPE HER NAME IN THE MATRIX."
112 PRINT"▒▒▒▒▒▒▒▒▒▒▒▒▒████";
113 INPUTA$
114 POKE33132,32:GOSUB197
115 PRINT"▒▒▒▒▒▒▒▒▒▒▒▒":GOSUB215
116 PRINT"▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒ANOTHER DRIVER'S NAME IS CARL."
117 PRINT"▒TYPE HIS NAME IN THE MATRIX."
118 PRINT"▒▒▒▒▒▒▒▒▒▒▒▒▒▒████";
119 INPUTA$
120 POKE33172,32
121 GOSUB197
122 PRINT"▒▒▒▒▒▒▒▒▒▒▒▒":GOSUB215
123 PRINT"▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒AS YOU LOOK AT MORE CLUES YOU"
124 PRINT"BEGIN TO MATCH CAR TO DRIVER."
125 PRINT"▒YOU CAN PUT YOUR BEST GUESS NEXT TO"
126 PRINT"THE DRIVERS NAME.
127 PRINT"▒FOR EXAMPLE, SUE SEEMS TO BE LINKED TO"
128 PRINT"▒A FORD SO TYPE FORD NEXT TO SUE."
129 GOSUB199
130 PRINT"▒▒▒▒▒▒▒▒▒▒▒███████████████";
131 INPUTA$
132 POKE33101,32
133 GOSUB215
134 PRINT"▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒AS YOU LOOK AT MORE CLUES,"
135 PRINT"▒YOU FIND THAT CARL IS LINKED TO A "
136 PRINT"▒TOYOTA, SO TYPE TOYOTA NEXT TO CARL."
137 GOSUB193
138 PRINT"▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒████████████████";
139 INPUTA$
140 POKE33181,32
141 GOSUB215
142 PRINT"▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒GUESSES FOR COLOR CAN BE FILLED IN"
143 PRINT"▒AS YOU BEGIN TO FIT THE INFORMATION"
144 PRINT"▒TOGETHER FROM THE CLUES. IF BILL "
145 PRINT"▒LIKES BLUE AND THE TOYOTA IS YELLOW"
146 PRINT"▒PUT THIS INFORMATION IN THE ▒MATRIX█"
147 PRINT"▒▒▒▒▒▒▒▒▒▒"SPC(23);:INPUTA$
148 POKE33071,32
149 PRINT"▒▒▒▒▒▒▒▒▒▒▒▒▒"SPC(23);:INPUTA$
150 POKE33191,32
```

226

```
151 GOSUB201:GOSUB215
152 PRINT"██████████████SUE'S RED FORD IS A WRECK."
153 PRINT"█THE BLUE HONDA IS BRAND NEW."
154 PRINT"█PATTI'S WHITE CHEVY HAS BALD TIRES."
155 PRINT"█████████"SPC(13);:INPUTA$
156 POKE33061,32
157 PRINT"██████████"SPC(13);:INPUTA$
158 POKE33141,32
159 PRINT"█████████"SPC(23);:INPUTA$
166 POKE33111,32
161 PRINT"██████████"SPC(23);:INPUTA$
162 POKE33151,32
163 GOSUB201:GOSUB215
164 PRINT"███████████████WHEN YOU FINISH YOUR █MATRIX█"
165 PRINT"█████████████████IT IS A GOOD IDEA TO ";
166 PRINT"RECHECK THE CLUES."
167 PRINT"THAT WAY YOU CAN CHECK TO SEE IF ALL"
168 PRINT"YOUR ANSWERS MAKE SENSE TOGETHER."
169 GOSUB201:GOSUB215
170 PRINT"█████████████BILL LIKES BLUE."
171 GOSUB201:GOSUB215
172 PRINT"█████████████THE TOYOTA IS YELLOW."
173 GOSUB201:GOSUB215
174 PRINT"█████████████SUE'S RED FORD IS A WRECK."
175 GOSUB201:GOSUB215
176 PRINT"█████████████THE BLUE HONDA IS BRAND NEW."
177 GOSUB201:GOSUB215
178 PRINT"█████████████PATTI'S WHITE CHEVY HAS ";
179 PRINT"BALD TIRES."
180 GOSUB201:GOSUB215
181 PRINT"██████████████WHEN THE █MATRIX█ IS COMPLETE ";
182 PRINT"AND YOU"
183 PRINT"HAVE DOUBLE CHECKED THE INFORMATION"
184 PRINT"FROM THE CLUES, YOU ARE READY TO CALL"
185 PRINT"FOR THE COMPUTER TO CHECK YOUR ANSWERS."
186 GOSUB201
187 PRINT"██████████"SPC(15)"GOOD LUCK!"
188 GOSUB195
189 PRINT"███████HINT:"
190 PRINT"█USE PENCIL. YOU MIGHT BE ERASING A LOT."
191 GOSUB199
192 END
193 FORP=1TO4500:NEXT
194 RETURN
195 FORP=1TO2500:NEXT
196 RETURN
197 FORP=1TO1000:NEXT
198 RETURN
199 FORP=1TO8000:NEXT
200 RETURN
```

```
201 B$="▮"
202 A$="PRESS RETURN TO CONTINUE"
203 PRINT"▮▮▮▮▮▮▮▮▮▮▮▮▮▮▮▮▮▮▮▮▮▮▮▮▮▮▮▮▮";A$
204 GETC$:IFC$=""THEN209
205 RETURN
206 A$=B$+A$:GOTO203
207 C=C+1:IFC=INT(C/2)*2THEN206
208 GOTO202
209 FORP=1TO250:NEXT:GOTO207
210 PRINT"▮▮▮▮▮▮▮"
211 FORI=1TO17
212 PRINT"                                       "
213 NEXTI
214 RETURN
215 PRINT"▮▮▮▮▮▮▮▮▮▮▮▮"
216 FORI=1TO12
217 PRINT"                                       "
218 NEXTI
219 RETURN
```

# APPENDIX G

## Transcript of Session 5A Conversation

## TRANSCRIPT OF SESSION 5A CONVERSATION

Group: 5A, Third session
Program: Global Travelers
Subjects: 5 seventh grade students; 4 male and 1 female
Solution time: 19:16 minutes
Special note: All subjects took part in this conversation, but it was difficult to accurately identify all voices. Only the distinctive voices of S1 and S5 will be specifically identified. Others will be identified as S when a speaker changes.

S1: Oh, this looks easy.

S: (Reading) "Your task is to match each traveler's name with the city they visited and the airlines they . . ."

S: Oh, that's hard!

S: Oh, we gotta do three of them.

S: Airlines?

S: (Reading) "There are 20 clues . . ."

S: "Remember your task is to match the name of each traveler with the city they visited and the airlines they used." "About a language? About a side trip? . . . the cities? . . . the language?

S1: Don't go in order, OK? And somebody write down every question we ask for so we don't ask . . .

S5: One thing! OK. All those things come off the same clues so all we have to do is keep this in the black and we'll get the same.

S1: No we don't, not necessarily, because if we ask questions . . .

S: (Typed L15) "Bob had not learned the local language because it had not been offered in his high school."

S1: So we know its Bob. Bob was one kid. Could you give me the other pencil. This one isn't sharp enough.

S: Sure.

S: Bob, let's see, Bob . . .

S1: Is somebody writing all these down?

S: Yes.

S1: OK. Write clue 15 so we know.

S: Hm . . . Number 5. "All the travelers are from the same city in the . . ."

S1: That doesn't matter though cause we aren't looking for what city . . .

S: We don't really need that.

S5: Yeah, but that means that there is no midwest that they will be visiting.

S: What is that? The midwest?

S: Midwestern.

S: Should I just do the end?

S: I don't know.

S: (Typed T7) "The TWA passenger visited the Great Wall of China, the only man . . .

S: ". . . visible from the moon . . ."

S: I didn't know that.

S: Somebody on TWA went to China.

S: What number is that?

S: Number 7.

S: Do you really think we need that where its says 'the only man-made structure'?

S: No, we don't need that.

S: We may!

S5: The only thing we really need is TWA went to China.

S: But that could be Bob because they don't teach Chinese.

S: Yeah, they could.

S: It still could be somebody else.

S1: How many people are there? Three?

S: It says, "Your task is . . ."

S: Um. Three. Three.

S: How do you know?

S: Cause it said in the beginning. You gotta read!

S1: Are you writing the whole thing down or just the . . . OK. Should I push it?

S: OK.

S1: Its your turn. N? What number? Pick a number.

S5: 20.

S: Sam!

S: It could have been Spanish!

S: Or French.

S: What do you say?

S1: Probably Spanish or French. But that still doesn't tell us the city.

S: Well, we know that one is Sam.

S: Wait a sec. Sam, Bob, airlines, TWA . . . Sam could . . .

S: What does that say?

S: One visited the Great Wall.

S5: The Great Wall is . . .

S: China!!

S5: That's the country. What city's it in?

S: I don't know.

S5: It says city. Not a country.

S: Could we have China as our regular city?

S1: Where is the Great Wall of China? It will probably tell it.

S5: Yeah. What is the language you take in high school?

S1: French or Spanish.

S: But it could be Hebrew also. It could be because if you went to . . .

S5: But it says high school.

S: It does? It could be a Jewish high school.

S1: What did I do? OK, go ahead.

S: Let's see . . . 6. "Sam especially enjoyed walking through the famous Hall of Mirrors . . ."

S: Oh, I know where that is!

S5: France!

S: Number 18.

S: We don't really have to know where they liked . . . what place they visited. Just the state.

S1: So Sam went to Paris.

S: That's in France, did you say?

S5: Yeah.

S: No, you put Paris.

S: Oh, its outside of Paris?

S: The country is France. But we can't use that.

S: (Writing). I'll put 'outside Paris'.

S: My turn.

S: OK.

S: If its outside Paris it could still be in France.

S1: It is in France.

S: Probably.

S: (Clue 10). "Two of the trav . . ." Well, we already know that!

S1: Well, that means that the rest are women.

S; There are only three.

S: That means that two are men.

S: OK. We'll take N.

S1: (Clue 12) Peking! That's in China!

S: Maybe that's where . . .

S: That's where -- all the cities in northern China . . .

S1: That means . . . and that's where the Great Wall was built.

S: But who went there? Does it just say one? Yeah. It just says one.

S: (Writing) Peking.

S5: What was the word? Was it a 'he' that could not speak the local language?

S: Yeah. It was Bob.

S1: OK. Whose turn?

S: It's my turn. Try 'About a city'.

S1: It might ask the same question.

S5: Let's keep with N.

S: That's a good idea.

S: 16.

S: "The visitor to this capitol city bought a sombrero . . ."

S: Mexico!

S: Where is . . .

S: Mexico! Mexico is a country.

S5: Mexico City!

S: It could be any . . .

S: It says capitol city.

S5: I still say Mexico City is the capitol.

S1: OK.

S: (Writing) OK.

S: It's not 'Deking', it's 'Peking'.

S1: Done?

S: Just put one by a sombrero to keep cool.

S1: Whose turn?

S5: N3.

S: "All travelers visited capitol cities."

S1: Peking is a capitol.

S: And Mexico City is . . .

S: Wait a second! Isn't Paris the capitol?

S: Of what?

S: France.

S: It said outside Paris.

S: It said outside Paris.

S5: So? It still could be Paris.

S1: Yeah. Cause he could go outside. So all we need is two airlines and a person.

S: Number 3.

S5: . . . and a place.

S1: No, we've got all the places. Paris, Peking, and Mexico City. And we need who visited where.

S: All right go ahead.
S1: N?
S: Yeah, we might as well. Don't push any of these others . . .
S: I'll take number 17.
S: Return. "Bob traveled farther than all the other travelers."
S1: If they all lived in . . .
S: In the midwest . . .
S1: China!
S: . . . that's where we live, right?
S1: Bob went to China. Bob went to Peking!
S: All right. That's half way around the world.
S5: All we have to do is get two airlines.
S1: (To writer) Just put 'fartherest than the others'.
S: We have to get the airlines next.
S1: Yeah.
S: Let's get clues about airlines.
S1: Yeah. So push 'A'.
S: We've already had A.
S: Yeah. But try again.
S: "The Braniff passenger exchanged dollars for pesos. . ." Pesos is Mexican!
S5: Yeah.
S1: The Braniff! What's a Braniff?
S5: It's an airline.
S1: It is?
S: Yeah.
S: What number is that?
S: So who visited Mexico? Do we know that yet?
S1: Whoever visited Mexico went on Braniff.
S5: So we need a person and an airline.
S: We've got to make sure . . .
S: . . . the spelling's right.
S1: OK. Make sure the spelling is all right.

S: (Writing) Hold on.

S1: Do you think if we put about an airline again, they will give us another clue? Look, we have left, 1, 2, 3 . . . We've done eleven.

S5: Let's try another about an airline.

S1: Yeah, but they might give us this one again. We could try it.

S: I don't think they would give it to us twice in a row.

S1: All right. "The Air France . . ."

S: "The Air France passenger could see the Eiffel Tower as they were landing."

S1: So that means Parish and Air France. That means . . .

S: What number is that?

S5: We've got all the airlines. All we need is . . .

S1: Bob is all finished now.

S: I thought . . .

S5: Bob and Sam.

S1: We don't know . . .

S5: Sam went to Paris.

S1: We don't know that. How do we know that?

S5: One of the clues was . . .

S: Cause it says he went to Paris.

S5: Yeah. But he took that language.

S1: OK. All right!

S: He took French probably.

S: Wait a second. It has to . . . Wait a second. Hold on. Bob went to China.

S1: Right. Peking.

S5: Where's the clue about Sam?

S: Ummm . . .

S5: Here it is.

S: That lady must have went to Mexico City with Braniff airlines. Now let's find out what is her name . . .

S1: Yeah.

S5: Sam could . . .

S1: And we could do that in one more clue.

S5: Sam could converse with the people he met because he had studied their language for 3 years in high school. So that is French.

S1: Yeah. OK. Ready?

S: OK. About a person. Do they have a person? (category)

S: No. About a language . . .

S: Let's go with the numbers then.

S1: Wait a second. Wait. "About . . ."

S: We already have about all these.

S: Try airlines.

S5: Do number. We have all the airlines.

S: Number 4.

S5: Do number 9.

S1: How about 17.

S: All right. Try it.

S: (Clue 17) "In the city that Bob visited everyone was dressed alike." Where did Bob go?

S1: Wait!

S5: Peking.

S1: Yeah. They all wear those things. OK. N. How about N. We want N.

S5: We want N13.

S1: 13?

S: "Sam bought several pieces of Limoges China . . ."

S1: From Paris. Yeah, that sounds OK. They are just trying to confuse us.

S: What's Limoges?

S: It's a brand.

S1: How about 14? Yes. No.

S5: Nine.

S: (Clue 14) "Most of the people in China . . ." Well, there was a wasted one.

S1: OK, now we'll try yours.

S5: (Clue 9) "Joan . . ." Joan!!

S: Joan! We got it!

S: We got it!

S: OK, so we press N.

S: Wait! Return.

S: N.

S5: Minus two.

S: Return.

S: OK, I'll do the first part . . .

S: I'll do Joan!

S1: I'll do Bob!

S: And I'll do Sam!

S1: OK. Go ahead.

(The answers were typed in and all answers were correct.)

S: We did it!

S: How many clues did we use?

S,S,S,S,S: (In chorus) 16 clues, Wow!

S: We're getting good. Let's see which ones we didn't even use. Don't push anything.

S: We didn't use numbers 4, 6, 8, 19. Is that the quickest anyone has ever done it?

S: We missed it by one? Oh-h-h.

# APPENDIX H

## Pilot Study 1

## PILOT STUDY #1

### The Purpose

The purpose of this study was to investigate the effect of a complex problem solving game strategy of logic and reasoning on early adolescents.

The research questions were:

1. Do students think that (a) a solution of the game is possible and that (b) their group is likely to solve it?
2. What methods do students use to reach a solution?
3. What type of interactions take place in the group?
4. What are the reactions of the students when the game is completed?

### The Procedure

The subjects in this study were three classes of seventh grade life science students at Clarenceville Junior High School in Livonia, Michigan, a suburb of Detroit.

In March of 1979, the author's life science students participated in the paper/pencil version of "Vertebrate Pets" group game as a review of a study unit on vertebrate animals.

The classes were divided into groups of four to six students, the game was introduced and played, and questionnaires were distributed upon completion of a correct solution.

## The Results

Fifteen groups participated in the group game sessions. Ten groups reached a correct solution and individually filled out a questionnaire for a total of N of 52. Result frequencies are given in Table 37.

TABLE 37

Response Frequencies of "Vertebrate Pets" Game With An N Of 52

| Questionnaire Item | Yes | No | Undecided |
|---|---|---|---|
| 1. Did you think the answer was possible? | 44 | 7 | 1 |
| 2. Did you think your group could find the solution? | 47 | 4 | 1 |
| 3. Did all clues seem important at first? | 22 | 30 | - |
| 4. Did you do any writing to get the answer? | 24 | 28 | - |
| 5. Did you use sentences? | 11 | 41 | - |
| 6. Did you use phrases? | 11 | 41 | - |
| 7. Did you use a matrix? | 28 | 24 | - |
| 8. Did you think the game was easy? | 21 | 29 | 11 |
| 9. Did you have fun? | 36 | 5 | 11 |
| 10. Do you feel that you learned the vertebrate characteristics today? | 33 | 4 | 5 |
| 11. Did anyone in your group seem to 'take over'? | 24 | 22 | 6 |
| 12. Did you feel that the group listened to you? | 32 | 8 | 8 |

Student responses indicated that 80% of the students believed that a solution was possible and 90% felt that their group could find a correct answer. Forty percent thought it was easy and 69% had fun trying to solve the problem. Sixty-three percent felt they had learned the vertebrate characteristics in the course of playing the game.

Even though the game was designed so that the information from all clues was necessary for a correct solution, in the earlier stages of the game 50% of the students did not consider all clues important to the solution. Fifty-four percent of the students let someone else record information and did not take notes themselves. Of the ones who did writing, 21% used sentence notes, 21% used phrases and 54% used a matrix strategy to organize the parts of the answer.

Responses concerning the interation within the group was limited to emergent leadership and feelings of personal contribution. Forty-six percent of the students felt that one individual in the group 'took over' the direction of the group. Sixty-two percent felt that they were an effective member of the group and that the group listened to what they had to say.

## The Discussion

The results of this exploratory study indicates that the students considered this game strategy fun, challenging, and an effective way to learn. They had a variety of learning and problem solving styles which contributed to the solution, but it was observed by the author that the matrix strategy was the most efficient way used to gain a faster solution. Unfortunately, no specific data was collected on this variable.

Group interactions varied from group to group. Some leadership facilitated the solution, some did not.

The student responses and researcher observations led the researcher to conclude that this game strategy has a useful potential for positive motivation and cognitive learning in its paper/pencil form. The strategy should be adaptable to any discipline area with similar results. If it could be adapted to a microcomputer format, the motivational combination could result in a powerful instructional tool.

## "VERTEBRATE PETS" 6-BITS by Dorothy A. Cox, 1978

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V-1. DO NOT SHOW THIS CARD
TO ANYONE IN YOUR GROUP.
BUT YOU CAN READ OR TELL
ANYONE WHAT IT SAYS.

2 of the pets were warm-blooded.

Joe's and Ted's pets do not have a voice to make sounds.

Oswald and Kiki have webbed feet.

One of these cards has a problem which your group must solve.

---

V-2. DO NOT SHOW THIS CARD
TO ANYONE IN YOUR GROUP.
BUT YOU CAN READ OR TELL
ANYONE WHAT IT SAYS.

Friday was a visiting day for pets.

Beth's and Mike's pets take good care of their young.

Ted had to bring a special container for his pet because it has no lungs.

Some of these facts may not be important to the solution of the problem.

---

V-4. DO NOT SHOW THIS CARD
TO ANYONE IN YOUR GROUP.
BUT YOU CAN READ OR TELL
ANYONE WHAT IT SAYS.

Esmerelda and Kiki have air sacs inside their bodies.

Joe's and Mike's pets are born alive.

Henrietta does not move around unless it is warm.

The pets represented all 5 kinds of vertebrates.

---

V-5. DO NOT SHOW THIS CARD
TO ANYONE IN YOUR GROUP.
BUT YOU CAN READ OR TELL
ANYONE WHAT IT SAYS.

Ted brought a cold-blooded pet.

Ann's pet is the champion jumper of the group of pets.

Kiki and Sparky are soft to touch.

Beth's pet has hollow bones.

## "VERTEBRATE PETS" 6-BITS (continued)

V-3. DO NOT SHOW THIS CARD
TO ANYONE IN YOUR GROUP.
BUT YOU CAN READ OR TELL
ANYONE WHAT IT SAYS.

Ann's pet has lungs but it also must breathe through its moist skin.

What kind of pet did each person bring to class and what was its name?

Hollow bones and air sacs make it easy for one pet to fly.

Patti did not have a pet.

V-6. DO NOT SHOW THIS CARD
TO ANYONE IN YOUR GROUP.
BUT YOU CAN READ OR TELL
ANYONE WHAT IT SAYS.

Esmerelda and Henrietta have scales.

Mike brought a comb to keep his pet looking neat.

Joe's pet has a long flexible hinge on its jaw to allow it to eat food bigger than its head size.

## Procedure for '6-Bits'

When first used as a preliminary exercise to an assigned investigation, the procedure is as follows:*

1. Have audience arrange themselves in groups of six (or the same number as cards), or have the chairs groups that way ahead of time.
2. Pass out the six cards, one to each in the group.
3. Tell audience there is a problem to solve, they can tell their group what is one their card but must not show it to others.
4. As the problem-solving session progresses:
    a. 5-8 minutes into the problem write on the board -- TRUST
    b. 8-12 minutes into problem write -- VISUAL DISPLAY
    c. 12-15 minutes into problem -- MATRIX
5. When all groups have finished discuss the process that the group went through:
    a. What kept you from solving the problem to begin with?
    b. What helped you to solve the problem later?
    c. What were some of the characteristics of the problem-solving?
        Did a leader emerge?
        Did you feel you were listened to?
6. Discuss with the group:

---

*Adapted from "Investigating Your Environment Series" by the U.S. Forest Service.

a. TRUST You must trust that the instructor gave you a solvable problem. You must trust each other.

b. RITUALISTIC LISTENING Polite listening is first, without really caring -- data has no relevance at first.

c. REAL LISTENING When statements become more meaninful, people tend to interrupt and say, "Say that again." Two things will change:

   (1) People will begin looking at each other. Someone will begin writing or diagramming a visual display.

   (2) Space factors will change -- people move closer together, move forward in their seats, sometimes change places.

d. COMMITMENT People feel more committed to a session if they contribute by saying something -- the earlier the better.

e. It's easier to talk to each other in a small group.

f. By utilizing the necessary contribution of each member of a group, we can often generalize to use as our process theme:

NONE OF US IS AS SMART AS ALL OF US

# APPENDIX I

## Pilot Study 2

## PILOT STUDY #2

### The Purpose

The purpose of this study was:

1. To determine the degree to which adolescents will recognize that they are using specifically stated problem solving skills while interacting with potential research games on a microcomputer.
2. To determine the extent to which the subjects perceive a need for improving specific problem solving skills.
3. To determine the extent to which the subjects believe that the microcomputer games have helped to improve specific problem solving skills.
4. To observe the student interactions and anecdotally report occurences that will facilitate conducting the final research.
5. To determine, in the opinion of the author, which microcomputer programs would best show the development of specific problem solving skills.

### The Procedure

The subjects in this study were seventh and eighth grade students from the study hall class at Clenceville Junior High School in Livonia, Michigan, a suburb of Detroit.

From October 2, 1979, to October 10, 1979, in six session, 15 students volunteered to participate in problem solving research activities with the Commodore PET microcomputer.

Students were given a brief introduction to the necessary mechanics of responding to computer directions and proceeded to follow directions given by the computer with no further directions by the researcher unless mechanical problems developed.

Four different microcomputer games and simulations were utilized. Two games were developed by the researcher: "Vertebrate Pets" and "Energy at Home." Two simulations were developed by other individuals: "Niche" is a published program from the magazine CREATIVE COMPUTING and "Mini-Edison" was developed by the Detroit Edison Company.

Two survey questionnaires were developed; one to be completed by the students at the end of each session and one to be utilized by the researcher while observing the session. Observational notes were taken by the researcher and audio tapes of the session conversations were recorded.

All sessions were conducted during the first hour class period from 8:10 to 9:00 a.m.

## The Results and Discussion

The intent of the researcher was to work with 20 students. But the study hall class was small and only 15 students signed up. Daily problems included the need by the student to do homework so that volunteers preferred to participate another day. Tape recorders could not be placed so that voices could be picked up with any clarity, at least with the typical school recorder.

The student questionnaire was used only with the two games, "Vertebrate Pets" and "Energy at Home," involving eight students. These eight students included five boys and three girls; one eighth grader and seven seventh graders; one group of two students and two groups of three students. The fourth group (two students) persisted with the game problem until they did not have adequate time to complete the questionnaire.

Therefore the questionnaire N is small and limited in its significance, but does indicate a useful pattern. There was overwhelming agreement within the three separate groups indicating that students recognized that they had used the eight specific problem solving skills and felt that the microcomputer game they had just played helped them develop that skill (see Table 38).

TABLE 38

Result Frequencies of Responses on the Student Questionnaire

| Problem Solving Skill | Skill was used | Skill needing improving | Microcomputer helped skill |
|---|---|---|---|
| 1. Recognizing problem | 8 | 3 | 5 |
| 2. Understanding problem | 8 | 2 | 5 |
| 3. Listening with comprehension | 3 | 1 | 5 |
| 4. Collecting data | 8 | 3 | 8 |
| 5. Organizing data | 8 | - | 7 |
| 6. Analyzing data | 8 | 4 | 8 |
| 7. Generating alternative solutions | 6 | 5 | 7 |
| 8. Reaching a solution | 5 | 3 | 8 |

Less than 50% of the students felt that their skills needed improvement in six of the eight skill areas. Fifty percent to 63% of the students felt that they needed improvement in two of the eight areas. No student indicated a felt need for developing the skill of organizing data (see Table 38).

All students stated that they understood the list of problem solving skills. They could suggest no additions to the list, deletions or vocabulary changes.

The research attempted to use an observer questionnaire which matched the student form in format and content with the purpose of comparing responses. This was attempted, but there seemed to be no accurate way of recording which skill was being used at a given time, the duration of that use, or how many times the skill was used. Therefore the observer questionnaire form was discarded and anecdotal notes were taken.

The remaining two groups of three students and two students interacted with the microcomputer simulations, "Niche" and "Mini-Edison." It became apparent to the researcher that the student questionnaire was not compatible with the given problem. The simulation contained too many variables that could not easily be categorized and/or controlled. In the opinion of the researcher, these simulations would not develop the desired focus for intended research and would not be studied further.

All students indicated that they enjoyed their experience, understood the topics, and would like to repeat their experience.

Although most of the students seemed to understand the steps of the problem solving strategy and recognize that they were using them, they did not feel that it was important to improve them to any degree, particularly the skill of organizing data. No student indicated that a lack of organizing material was a factor in their deliberations. Yet after analyzing their working papers and listening to their conversations, it is the researcher's opinion that the key (or at least one of the keys) to dealing with 20 clues demanding a complex solution is to have a workable plan of organizing data that can transfer readily to a similar situation.

It is recognized that learners have many different learning styles and instruction should accomodate those learning styles (Dunn and Dunn, 1977). The subjects of this pilot research certainly reflected that philosophy. The method and style varied from group to group. One group of two wrote nothing for twenty minutes, did not seem to understand that the problem had a complex answer, and conversed very little. Another group of two did not converse at all but used body language to indicate turn-taking. Other groups discussed every clue and waited for consensus on ideas. Some used a matrix organization of alternative solutions, while others wrote out every clue in its entirety.

Whatever the style, students were motivated to try whatever is put on the display screen of a computer providing an opportunity for a unique way of developing problem solving skills.

STUDENT QUESTIONNAIRE

Student I.D. ________

NAME OF SIMULATION ________________________

IN THIS SIMULATION YOU HAVE USED SEVERAL PROBLEM SOLVING SKILLS TO REACH A SOLUTION. PLEASE ANSWER THE FOLLWOING QUESTIONS ABOUT YOURSELF OR YOUR TEAM.

| Problem Solving Skill | Which skill did you use? ( ✓ ) | Which skill do you feel needs improving? ( ✓ ) | Do you feel this microcomputer simulation helped you improve this skill? (yes,no) |
|---|---|---|---|
| 1. Recognizing the problem | | | |
| 2. Defining or understanding the problem | | | |
| 3. Listening with comprehension | | | |
| 4. Collecting data (facts) | | | |
| 5. Organizing the data (facts) | | | |
| 6. Analyzing the data (facts) | | | |
| 7. Generating alternative solutions | | | |
| 8. Reaching your solution | | | |

OBSERVER QUESTIONNAIRE Student I.D. ________

SIMULATION ________________________________

| Problem Solving Skill | Skill Used By Student ( ✓ ) | Skill Needing Improvement ( ✓ ) & (Rank) | Number Times Skill Was Used (Tally) | Comments |
|---|---|---|---|---|
| 1. Recognizing the problem | | | | |
| 2. Defining or understanding the problem | | | | |
| 3. Listening with comprehension | | | | |
| 4. Collecting data (facts) | | | | |
| 5. Organizing the data (facts) | | | | |
| 6. Analyzing the data (facts) | | | | |
| 7. Generating alternative solutions | | | | |
| 8. Reaching the solution | | | | |

# APPENDIX J

## Schedule of Research Sessions

## Schedule of Research Sessions

| Week | Monday | Tuesday | Wednesday | Thursday | Friday | Hour |
|---|---|---|---|---|---|---|
| 1 | (Cog. Inv.<br>School 1) | 2D<br>3D | 2Dm*<br>3Dm | 2D<br>3D | (Recruiting<br>School 2) | 6th<br>7th |
| 2 | 2B<br>2A | 5A<br>2F | 5A<br>2F | 5A<br>2F | (Cog. Inv.<br>School 2) | 6th<br>7th |
| 3 | 2Bm<br>2A | 3F<br>5C | 3F<br>5Cm | 3F<br>5C | (Recruiting<br>School 3) | 6th<br>7th |
| 4 | 2B<br>2A | 2E<br>5E | 2E<br>5E | 2E<br>5E | (Vacation<br>No School) | 6th<br>7th |
| 5 | (Vacation<br>No School) | (Vacation<br>No School) | (Cog. Inv.<br>School 3) | 3C<br>2C | 1E<br>1F | 6th<br>7th |
| 6 | 3E<br>5F | 5B<br>5D<br>1D | -<br>- | 3C<br>2C | 1Em<br>1F | 6th<br>7th<br>After School |
| 7 | 3D<br>5F abs.<br>3A | 5B abs.<br>5D<br>1D | -<br>- | 3C abs.**<br>2C | 1E<br>1F | 6th<br>7th<br>After School |
| 8 | 3E abs.<br>3A<br>1D | (Inservice<br>No School) | 5B abs.<br>5D | -<br>- | -<br>- | 6th<br>7th<br>After School |
| 9 | -<br>- | 3B<br>3A<br>1B | 3B<br>1B | 3B<br>1B | -<br>- | 6th<br>7th<br>After School |
| 10 | 1A<br>1C | 1Am<br>1Cm | 1A<br>1C | (Cog. Inv.<br>School 2) | (Vacation<br>No School) | 6th<br>7th |
| 11 | -<br>- | 5F<br>5B | 3C<br>3E | (Cog. Inv.<br>School 4) | -<br>- | 6th<br>7th |
| 12 | -<br>- | 5Fm<br>5Bm abs. | 3C<br>3Em | 5B<br>- | - | 6th<br>7th |
| 13 | -<br>- | 5F<br>- | 3C<br>3E | 5Bm<br>- | -<br>- | 6th<br>7th |
| 14 | - | - | - | 5B | - | 6th |

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*2Dm refers to 2 subjects, sequence order D with matrix training.

**3Cabs. refers to individual absence in group; group withdrawn from research.

# BIBLIOGRAPHY

## BIBLIOGRAPHY

Amick, Daniel J. and Walberg, Herbert J. (Eds.). *Introductory Multivariate Analysis*. New York: McCutchan Publishing Corp., 1975.

Bales, Robert F. and Borgatta, Edgar F. "Size of Group as a Factor in the Interaction Profile." In *Small Groups: Studies in Social Interaction*. Edited by Hare, Borgatta, and Bales. New York: Alfred A. Knopf, 1955.

Banet, Bernard. "Computers and Early Learning." *Creative Computing* 4 (September-October 1978): 90-95.

Barnlund, Dean C. "A Comparative Study of Individual Minority and Group Judgement." *Journal of Abnormal and Social Psychology* 58 (1959): 55-60.

Barrette, Pierre P. "Microcomputers in Education." *Compute* 1 (Fall 1979): 34-38.

Bell, Frederick H. "Classroom Computers: Beyond the 3 R's." *Creative Computing* 5 (September 1979): 68-70.

Berger, Carl F.; Newman, Richard S.; and Cox, Dorothy A. "Applications of Scientific and Mathematical Processes by Adolescents Using Microcomputers. Part I: Estimation: The Effect of Information on the Determination of Linear Distance." An unpublished paper presented to the 53rd annual meeting of the National Association for Research in Science Teaching, Boston, Mass., April 1980.

Biglan, Barbara Ruth. "The Use of Problem Solving Strategies in Relation to Selected Learner Characteristics of Sixth and Eighth Grade Students." An unpublished dissertation, The University of Pittsburgh, 1977.

Billings, Karen. "Microcomputers in Education: Now and in the Future." *Microcomputing* (June 1980): 100-102.

Brown, B. R. and Gilman, A. "Expressed Student Attitudes Under Several Conditions of Automated Programmed Instruction." *Contemporary Education* 40 (1969): 286-289.

Bruner, Jerome S. "The Act of Discovery." *Harvard Educational Review* 31 (1961): 21-32.

________. *The Process of Education*. Cambridge, Mass.: Harvard University Press, 1965.

________. "The Process of Education Revisited." *Phi Delta Kappan* 53 (September 1971): 18-21.

Campbell, J. Olin. "Personal Computers in the Classroom." *Interface Age* 4 (October 1979): 60-62.

Cartwright, Glenn F. and Cohen, Penny. "Individualized Group Computer-Assisted Instruction." Paper presented to the American Educational Research Association, New York, April, 1977.

Craig, John. "Ten Years From Now? Editorial." *Creative Computing* 5 (June 1979): 6-7.

Dewey, John. *How We Think*. Boston: Heath, 1910.

Doerr, Christine. *Microcomputers and the 3 R's: A Guide for Teachers*. New Jersey: Hayden Book Company, 1979.

Dunn, Rita S. and Dunn, Kenneth J. *Teaching Students Through Their Learning Styles: A Practical Approach*. Reston, Va.: Reston Publishing Company, 1978.

Elliott, Walt. "Science Teaching in the 21st Century." *Science Teacher* 43 (January 1976): 25-26.

Gagne, Robert M. "The Learning Requirements for Enquiry." *Journal of Research in Science Teaching* 1 (1963): 144-153.

Gerrell, Glen E. *Computer Assisted Instruction of College Physics Students in Small Groups. Final Report*. Washington, D. C.: National Center for Educational Research and Development, (DHEW/OE), 1972.

Goldberg, Albert L. "Now That the Microcomputer is Here ...." *Focus*, published by Michigan Association for Supervision and Curriculum Development (January 1980): 25-30.

Greeno, J. G. "A Study of Problem Solving." In R. Glaser (Ed.), *Advances in Instructional Psychology*, Vol. 1. Hillsdale, N. J.: Lawrence Erlbaum Associates, 1978.

Haertel, Geneva D. "Literature Review of Early Adolescence and Implications for Science Education Programming." *Early Adolescence, Perspectives, and Recommendations*. Washington, D. C.: National Science Foundation, Superintendent of Documents, U. S. Government Printing Office, 1978.

________. "The Education of Youth in the Middle Years." A joint position paper of the Michigan Association of Secondary School Principals and the Michigan Department of Education, January 1976.

________. *Science--A Process Approach, Commentary for Teachers.* AAAS/Xerox Corporation, 1970.

Hall, K. A. "Computer-Assisted Instruction: Problems and Performance." *Phi Delta Kappan* 52 (1971): 628-631.

Hare, A. Paul. "A Study of Interaction and Consensus in Different Sized Groups." *American Sociological Review* 17 (1952): 261-267.

Heyns, R. W. "Functional Analysis of Group Problem Solving Behavior." Paper presented at Conference Research, Department of Psychology, The University of Michigan, Ann Arbor, Mich., 1948. (Mimeographed)

Inhelder, B. and Piaget, J. *The Growth of Logical Thinking From Childhood and Adolescence*. New York: Basic Books, Inc., 1958.

Inman, Don. "Apples, Computers and Teachers." *Interface Age* 4 (October 1979): 68-72.

Knight, Carlton W., Jr. and Dunkleberger, Gary E. "The Influence of Computer-Managed Self-Paced Instruction on Science Attitudes of Students." *The Journal of Research in Science Teaching* 14 (1977): 551-555.

Larsen, Sally G. "Kids and Computers: The Future is Today." *Creative Computing* 5 (September 1979): 58-60.

Lichtman, David. "Survey of Educator's Attitudes Toward Computers." *Creative Computing* 5 (January 1979): 48-50.

McGuire, Christine. "Simulation Technique in the Teaching and Testing of Problem Solving Skills." *Occasional Paper Series--Science Paper 8*. Presented at the 46th Annual Meeting of the National Association for Research in Science Teaching, March, 1973.

Mathis, A.; Smith, T.; and Hansen, D. "College Students' Attitudes Toward Computer Assisted Instruction." *Journal of Educational Psychology* 61 (1970): 46-51.

Mayer, Richard E. *Thinking and Problem Solving: An Introduction to Human Cognition and Learning*. New York: Scott, Foresman and Company, 1977.

Morris, Charles G. "Changes in Group Interaction During Problem Solving." *The Journal of Social Psychology* 81 (1970): 157-165.

"NSTA Position Statement on School Science Education for the 1970s." *Readings in Science Education for the Elementary School.* Edited by Victor and Learner. New York: Macmillan Publishing Company, 1975.

Polya, G. *How to Solve It*. New York: Doubleday Anchor, 1957.

Renner, John W.; Stafford, Don G.; and Ragan, William B. *Teaching Science in the Elementary School*. New York: Harper and Row Publishers, 1973.

Scherer, Donald R. "The Micro in a Small School and at the University Level." *Interface Age* 4 (October 1979): 65-66.

Schwartz, H. A. and Long, H. S. "A Study of Remote Industrial Training Via Computer Assisted Instruction." *Journal of Applied Psychology* 51 (1967): 11-16.

Shaw, Marjorie E. "A Comparison of Individuals and Small Groups in the Rational Solution of Complex Problems." *American Journal of Psychology* 44 (1932): 491-504.

Simon, Herbert A. and Newell, Allen. "Human Problem Solving: The State of the Theory in 1970." *American Psychologist* 26 (1971): 145-159.

Stapp, William B. and Cox, Dorothy A. (Eds.). *Environmental Education Activities Manual*. Farmington Hills, Mich.: 1979.

Stavrides, Marie K. "Computer Days." *Science and Children* 16 (September 1978): 18-19.

Swan, James A. "An Analysis of Attitudes and Coping Strategies of High School Youth: Response to Air Pollution." An unpublished dissertation, The University of Michigan, 1969.

Taba, Hilda. *Curriculum Development*. New York: Harcourt, Brace and World, Inc., 1962.

Tanner, Daniel and Tanner, Laurel N. *Curriculum Development: Theory Into Practice*. New York: Macmillan Publishing Company, Inc., 1975.

Taylor, D. W. and Faust, W. L. "Twenty Questions: Efficiency in Problem Solving as a Function of Size of a Group." *Journal of Experimental Psychology* 44 (1952): 360-368.

Thomas, David B. "The Effectiveness of Computer-Assisted Instruction in Secondary Schools." *Association for Educational Data Systems (AEDS) Journal* 12 (Spring 1979).

Tinker, Robert F. "Electronics in Science Teaching." *The Science Teacher* 46 (September 1979): 27-32.

"Toward An Action Plan: A Report on the Intergovernmental Conference on Environmental Education." A paper developed by the Subcommittee on Environmental Education, HEW, Supt. of Documents, U. S. Government Printing Office, March, 1978.

Tuckman, B. W. *Conducting Educational Research*. New York: Harcourt, Brace and Jovanovich, Inc., 1972.

Wallas, G. *The Art of Thought*. New York: Harcourt and Brace, 1926.

Whitfield, J. W. "An Experiment in Problem Solving." *Quarterly Journal of Experimental Psychology* 3 (1951): 184-197.

Windbigler, Jerrol. "Individualizing Chemistry With a Computer." *The Science Teacher* 45 (January 1978): 24-25.

Wollman, Warren. *Developmental Implications of Science Teaching: Early Adolescents*. Columbus, Ohio: National Association for Research in Science Teaching, ERIC Clearinghouse for Science, Mathematics and Environmental Education, 1978.

Yinger, Joanne and Eckland, Ruth. *Problem Solving With Children*. San Francisco, Calif.: Far West Laboratory for Educational Research and Development, 1975.

Zimet, Carl N. and Schneider, Carol. "Effect of Group Size on Interaction in Small Groups." *Journal of Social Psychology* 77 (April 1969): 177-187.

Zinn, Karl L. "Computers in Science Teaching: Today and Tomorrow." In *What Research Says to the Science Teacher*, Vol. 2. Edited by Mary Budd Rowe. NSTA, 1979.